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# PROCEEDINGS

OF

# The American Association

FOR THE

# ADVANCEMENT OF SCIENCE,

FIFTY-SIXTH AND FIFTY-SEVENTH MEETINGS

HELD AT

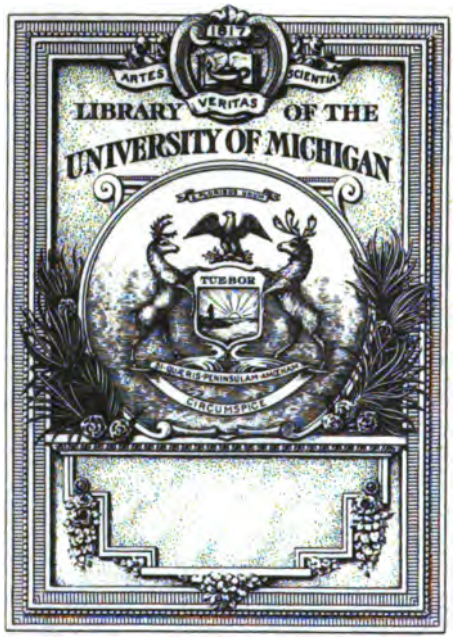
ITHACA, N. Y., JUNE 28 TO JULY 3, 1906.
(Special Summer Meeting.)

AND

NEW YORK CITY, N. Y., DECEMBER 27, 1906,
TO JANUARY 2, 1907.

PUBLISHED BY THE PERMANENT SECRETARY

1907.

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# PROCEEDINGS

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OF

# The American Association

FOR THE

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1907.

EDITED BY

L. O. HOWARD,

*Permanent Secretary.*

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PRESS OF GIBSON BROS.
WASHINGTON, D. C.
1908.

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*Elected by the Council.*—(For one year) FRANZ BOAS, E. L. NICHOLS. W. F. WILCOX; (for two years) EDGAR F. SMITH, H. B. WARD, WM. TRELEASE; (for three years) J MCK. CATTELL, J. M. COULTER, H. F. OSBORN.

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[1] All Committees are expected to present their reports to the COUNCIL not later than the third day of the meeting. Committees sending their reports to the permanent Secretary one month before a meeting can have them printed for use at the meeting.

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## Meetings and Officers of the Association of American Geologists and Naturalists.

| Meeting. | Date. | Place. | Chairman. | Secretary. | Assistant Secretary. | Treasurer. |
|---|---|---|---|---|---|---|
| 1st | April 2, 1840, | Philadelphia, | Edw. Hitchcock,* | L. C. Beck,* | | |
| 2d | April 5, 1841, | Philadelphia, | Benj. Silliman,* | L. C. Beck,* | B. Silliman, Jr.,*<br>C. B. Trego,* | |
| 3d | April 25, 1842, | Boston, | S. G. Morton,* | C. T. Jackson,* | J. D. Whitney,*<br>M. B. Williams,* | |
| 4th | April 26, 1843, | Albany, | Henry D. Rogers,* | B. Silliman, Jr.,* | | John Locke.* |
| 5th | May 8, 1844, | Washington, | John Locke,* | B. Silliman, Jr.,*<br>O. P. Hubbard, | | Douglas Houghton.* |
| 6th | April 30, 1845, | New Haven, | Wm. B. Rogers,* | B. Silliman, Jr.,*<br>J. Law. Smith,* | | Douglas Houghton.* |
| 7th | Sept. 2, 1846, | New York, | C. T. Jackson,* | B. Silliman, Jr.,* | | E. C. Herrick.* |
| 8th | Sept. 20, 1847, | Boston, | Wm B. Rogers,*† | Jeffries Wyman,* | | B. Silliman, Jr.* |

* Deceased.

† Professor Rogers, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

| Meetings | Place | Date | Members in attendance | Number of members |
|---|---|---|---|---|
| 1 | Philadelphia | Sept. 20, 1848 | ? | 461 |
| 2 | Cambridge | Aug. 14, 1849 | ? | 540 |
| 3 | Charleston | Mar. 12, 1850 | ? | 682 |
| 4 | New Haven | Aug. 19, 1850 | ? | 704 |
| 5 | Cincinnati | May 5, 1851 | 87 | 800 |
| 6 | Albany | Aug. 19, 1851 | 194 | 769 |
| 7 | Cleveland | July 28, 1853 | ? | 940 |
| 8 | Washington | April 26, 1854 | 168 | 1004 |
| 9 | Providence | Aug 15, 1855 | 166 | 605 |
| 10 | 2d Albany | Aug. 20, 1856 | 381 | 722 |
| 11 | Montreal | Aug. 12, 1857 | 351 | 946 |
| 12 | Baltimore | April 28, 1858 | 190 | 962 |
| 13 | Springfield | Aug. 3, 1859 | 190 | 862 |
| 14 | Newport | Aug. 1, 1860 | 135 | 644 |
| 15 | Buffalo | Aug. 15, 1866 | 79 | 637 |
| 16 | Burlington | Aug. 21, 1867 | 73 | 415 |
| 17 | Chicago | Aug. 5, 1868 | 259 | 686 |
| 18 | Salem | Aug 18, 1869 | 244 | 511 |
| 19 | Troy | Aug. 17, 1870 | 188 | 536 |
| 20 | Indianapolis | Aug. 16, 1871 | 196 | 668 |
| 21 | Dubuque | Aug. 15, 1872 | 164 | 610 |
| 22 | Portland | Aug. 20, 1873 | 195 | 670 |
| 23 | Hartford | Aug. 12, 1874 | 224 | 722 |
| 24 | Detroit | Aug. 11, 1875 | 165 | 807 |
| 25 | 2d Buffalo | Aug. 23, 1876 | 215 | 867 |
| 26 | Nashville | Aug. 29, 1877 | 173 | 953 |
| 27 | St. Louis | Aug. 21, 1878 | 134 | 962 |
| 28 | Saratoga | Aug. 27, 1879 | 256 | 1030 |
| 29 | Boston | Aug. 25, 1880 | 997 | 1555 |
| 30 | 2d Cincinnati | Aug. 17, 1881 | 500 | 1699 |
| 31 | 2d Montreal | Aug. 23, 1882 | 937 | 1922 |
| 32 | Minneapolis | Aug. 15, 1883 | 328 | 2033 |
| 33 | 2d Philadelphia | Sept. 3, 1884 | 1261* | 1981 |
| 34 | Ann Arbor | Aug. 26, 1885 | 364 | 1956 |
| 35 | 3d Buffalo | Aug. 18, 1886 | 445 | 1886 |
| 36 | New York | Aug. 10, 1887 | 729 | 1956 |
| 37 | 2d Cleveland | Aug. 14, 1888 | 342 | 1964 |
| 38 | Toronto | Aug. 26, 1889 | 424 | 1952 |
| 39 | 2d Indianapolis | Aug. 19, 1890 | 364 | 1944 |
| 40 | 2d Washington | Aug. 19, 1891 | 653† | 2054 |
| 41 | Rochester | Aug. 17, 1892 | 456 | 2037 |
| 42 | Madison | Aug. 17, 1893 | 290 | 1939 |
| 43 | Brooklyn | Aug. 15, 1894 | 488 | 1802 |
| 44 | 2d Springfield | Aug. 28, 1895 | 368 | 1913 |
| 45 | 4th Buffalo | Aug. 24, 1896 | 333 | 1890 |
| 46 | 2d Detroit | Aug. 9, 1897 | 283‡ | 1782 |
| 47 | 2d Boston | Aug. 22, 1898 | 903 | 1729 |
| 48 | Columbus | Aug. 21, 1899 | 353 | 1721 |
| 49 | 2d New York | June 25, 1900 | 434 | 1925 |
| 50 | Denver | Aug. 24, 1901 | 311 | 2703 |
| 51 | Pittsburg | June 28 to July 3, 1902 | 435 | 3473 |
| 52 | 3d Washington | Dec. 27, 1902, to Jan. 2, 1903 | 975 | 3596 |
| 53 | 2d St. Louis | Dec. 28, 1903, to Jan. 2, 1904 | 385 | 4075 |
| 54 | 3d Philadelphia | Dec. 27–31, 1904 | 890 | 4175 |
| 55 | New Orleans | Dec. 28, 1905, to Jan. 2, 1906 | 233 | 4357 |
| 56 | Ithaca | June 28 to July 3, 1906. | 232 | 4425 |
| 57 | 3d New York | Dec. 27, 1906, to Jan. 2, 1907. | 934 | 4498 |

* Including 303 Members of the British Association and 9 other foreign guests.
† Including 24 Foreign Honorary Members for the meeting.
‡ Including 15 Foreign Honorary Members and Associates for the meeting.

# Officers of the Meetings of the Association.

[The number before the name is that of the meeting; the year of the meeting follows the name; the asterisk after a name indicates that the member is deceased.]

## PRESIDENTS.

1. { WM. B. ROGERS,* 1848. / W. C. REDFIELD,* 1848.
2. JOSEPH HENRY,* 1849.
3. { A. D. BACHE,* March meeting, 1850, in the absence of JOSEPH HENRY.*
4. { August meeting, 1850.
5. { May meeting, 1851.
6. LOUIS AGASSIZ,* August meeting, 1851.
(No meeting in 1852.)
7. BENJAMIN PIERCE,* 1853.
8. JAMES D. DANA,* 1854.
9. JOHN TORREY,* 1855.
10. JAMES HALL,* 1856.
11. { ALEXIS CASWELL,* 1857, in place of J. W. BAILEY,* deceased. 1858, in the absence of JEFFRIES WYMAN.*
12. { 
13. STEPHEN ALEXANDER,* 1859.
14. ISAAC LEA,* 1860.
(No meetings for 1861–65.)
15. F. A. P. BARNARD,* 1866.
16. J. S. NEWBERRY,* 1867.
17. B. A. GOULD,* 1868.
18. J. W. FOSTER,* 1869.
19. T. STERRY HUNT,* 1870, in the absence of WM. CHAUVENET.*
20. ASA GRAY,* 1871.
21. J. LAWRENCE SMITH,* 1872.
22. JOSEPH LOVERING,* 1873.
23. J. L. LECONTE,* 1874.
24. J. E. HILGARD,* 1875.
25. WILLIAM B. ROGERS,* 1876.
26. SIMON NEWCOMB, 1877.
27. O. C. MARSH,* 1878.
28. G. F. BARKER, 1879.
29. LEWIS H. MORGAN,* 1880.
30. G. J. BRUSH, 1881.
31. J. W. DAWSON, 1882.
32. C. A. YOUNG, 1883.
33. J. P. LESLEY,* 1884.
34. H. A. NEWTON;* 1885.
35. EDWARD S. MORSE, 1886.
36. S. P. LANGLEY,* 1887.
37. J. W. POWELL,* 1888.
38. T. C. MENDENHALL, 1889.
39. G. LINCOLN GOODALE, 1890.
40. ALBERT B. PRESCOTT,* 1891.
41. JOSEPH LECONTE,* 1892.
42. WILLIAM HARKNESS,* 1893.
43. DANIEL G. BRINTON,* 1894.
44. E. W. MORLEY, 1895.
45. { EDWARD D. COPE,* 1896. THEODORE GILL, as senior vice-president acted after the death of Prof. COPE.
46. { WOLCOTT GIBBS, 1897, absent. W J MCGEE, Acting President.
47. F. W. PUTNAM, 1898.
48. { EDWARD ORTON,* 1899. GROVE K. GILBERT, elected by the General Committee December, 1899, to fill the vacancy caused by the death of Prof. ORTON.
49. R. S. WOODWARD, 1900.

50. C. S. MINOT, 1901.
51. ASAPH HALL, 1902.
52. IRA REMSEN, 1903.
53. CARROLL D. WRIGHT, 1904.
54. W. G. FARLOW, 1905.
55. C. M. WOODWARD, 1906.
56. W. H. WELCH, 1906.
57. W. H. WELCH, 1907.

## VICE-PRESIDENTS.

There were no Vice-Presidents until the 11th meeting, when there was a single Vice-President for each meeting. At the 24th meeting, the Association met in Sections A and B, each presided over by a Vice-President. At the 31st meeting nine sections were organized, each with a Vice-President as its presiding officer. In 1886 Section G (Microscopy) was given up. In 1892, Section F was divided into F, Zoology; G, Botany.

### 1857–1874.

11. ALEXIS CASWELL,* 1857, acted as President.
12. JOHN E. HOLBROOK,* 1858, not present.
13. EDWARD HITCHCOCK,* 1859.
14. B. A. GOULD,* 1860.
15. B. A. GOULD,* 1866, in the absence of R. W GIBBES.
16. WOLCOTT GIBBS, 1867.
17. CHAS. WHITTLESEY,* 1868.
18. OGDEN N. ROOD, 1869.
19. T. STERRY HUNT,* 1870, acted as President.
20. G. F. BARKER, 1871.
21. ALEX. WINCHELL,* 1872.
22. A. H. WORTHEN,* 1873, not present.
23. C. S. LYMAN,* 1874.

### 1875–1881.

*Section A.—Mathematics, Physics, and Chemistry.*

24. H. A. NEWTON,* 1875.
25. C. A. YOUNG, 1876.
26. R. H. THURSTON,* 1877, in the absence of E. C. PICKERING.
27. R. H. THURSTON,* 1878.
28. S. P. LANGLEY,* 1879.
29. ASAPH HALL, 1880.
30. WM. HARKNESS,* 1881, in the absence of A. M. MAYER.*

*Section B.—Natural History.*

24. J. W. DAWSON, 1875.
25. EDWARD S. MORSE, 1876.
26. O. C. MARSH,* 1877.
27. AUG R. GROTE, 1878.
28. J. W. POWELL,* 1879.
29. ALEX. AGASSIZ, 1880.
30. EDWARD T. COX, 1881, in the absence of GEORGE ENGELMANN.*

## CHAIRMEN OF SUBSECTIONS, 1875–1881.

*Subsection of Chemistry.*

24. S. W. JOHNSON, 1875.
25. G. F. BARKER, 1876.
26. N. T. LUPTON,* 1877.
27. F W. CLARKE, 1878.
28. F. W. CLARKE, 1879, in the absence of IRA REMSEN.
29. J. M. ORDWAY, 1880.
30. G. C. CALDWELL, 1881, in the absence of W. R. NICHOLS.*

*Subsection of Microscopy.*

25. R. H. WARD, 1876.
26 R. H. WARD, 1877.
27. R. H. WARD, 1878, in the absence of G. S. BLACKIE.*
28. E. W. MORLEY, 1879.
29. S. A. LATTIMORE, 1880.
30. A. B. HERVEY, 1881.

*Subsection of Anthropology.*

24. LEWIS H. MORGAN,* 1875.
25. LEWIS H. MORGAN,* 1876.
26. DANIEL WILSON,* 1877, not present.
27. United with Section B.
28. DANIEL WILSON,* 1879.
29. J. W. POWELL,* 1880.
30. GARRICK MALLERY,* 1881.

*Subsection of Entomology.*

30. J. G. MORRIS,* 1881.

## VICE-PRESIDENTS OF SECTIONS, 1882–

*Section A.—Mathematics and Astronomy.*

31. W. A. ROGERS,* 1882, in the absence of WM. HARKNESS.*
32. W. A. ROGERS,* 1883.
33. H. T. EDDY, 1884.
34. WM. HARKNESS,* 1885, in the absence of J. M. VAN VLECK.
35. J. W. GIBBS,* 1886.
36. J. R. EASTMAN, 1887, in place of W. FERREL,* res'd.
37. ORMOND STONE, 1888.
38. R. S. WOODWARD, 1889.
39. S. C. CHANDLER, 1890.
40. E. W. HYDE, 1891.
41. J. R. EASTMAN, 1892.
42. C. L. DOOLITTLE, 1893.
43. { G. C. COMSTOCK, 1894. / EDGAR FRISBY, 1894.
44. EDGAR FRISBY, 1895, in place of E. H. HOLDEN, resigned.
45. ALEX. MACFARLANE, 1896, in place of WM. E. STORY, resigned.
46. W. W. BEMAN, 1897.
47. E. E. BARNARD, 1898.
48. ALEX. MACFARLANE, 1899.
49. ASAPH HALL, JR., 1900.
50. JAMES MACMAHON, 1901.
51. G. W. HOUGH, 1902.
52. GEORGE BRUCE HALSTED, 1903.
53. O. H. TITTMANN, 1904.
54. ALEXANDER ZIWET, 1905.
55. ALEXANDER ZIWET, 1906, in the absence of W. S. EICHELBERGER.
56. EDWARD KASNER, 1906.
57. EDWARD KASNER, 1907.

*Section B.—Physics.*

31. T. C. MENDENHALL, 1882.
32. H. A. ROWLAND,* 1883.

VICE-PRESIDENTS OF SECTIONS, CONTINUED.

33. J. TROWBRIDGE, 1884.
34. S. P. LANGLEY,* 1885, in place of C.F.BRACKETT, res'd.
35. C. F. BRACKETT, 1886.
36. W. A. ANTHONY, 1887.
37 A. A. MICHELSON, 1888.
38. H. S. CARHART, 1889.
39. CLEVELAND ABBE, 1890.
40. F. E. NIPHER, 1891.
41. B. F. THOMAS, 1892.
42. E. L. NICHOLS, 1893.
43. WM. A. ROGERS, 1894.
44. W.LECONTE STEVENS, 1895.
45. CARL LEO MEES, 1896.
46. CARL BARUS, 1897.
47. F. P. WHITMAN, 1898.
48. ELIHU THOMSON, 1899.
49. ERNEST MERRITT, 1900.
50. D. B. BRACE,* 1901.
51. W. S. FRANKLIN, 1902.
52. ERNEST F. NICHOLS, 1903.
53. E. H. HALL, 1904.
54. WM. F. MAGIE, 1905.
55. HENRY CREW, 1906.
56. W. C. SABINE, 1906.
57. W. C. SABINE, 1907.
58. D. C. MILLER, 1908.

*Section C.—Chemistry.*

31. H. C. BOLTON,* 1882.
32. E. W. MORLEY, 1883.
33. J. W. LANGLEY, 1884.
34. N. T. LUPTON,* 1885, in the absence of W. R. NICHOLS.
35. H. W. WILEY, 1886.
36. A. B. PRESCOTT,* 1887.
37. C. E. MUNROE, 1888.
38. W. L. DUDLEY, 1889.
39. R. B. WARDER, 1890.
40. R. C. KEDZIE, 1891.
41. ALFRED SPRINGER, 1892.
42. EDWARD HART, 1893.
43. T. H. NORTON, 1894.
44. WM. MCMURTRIE, 1895.
45. W. A. NOYES, 1896.
46. W. P. MASON, 1897.
47. EDGAR F. SMITH, 1898.
48. F. P. VENABLE, 1899.
49. JAS. LEWIS HOWE, 1900.
50. JOHN H. LONG, 1901.
51. H. A. WEBER, 1902.
52. CHARLES BASKERVILLE, 1903.
53. W. D. BANCROFT, 1904.
54. L. P. KINNICUTT, 1905.
55. L P. KINNICUTT, 1906, in absence of C. F. MABERY.
56. CLIFFORD RICHARDSON, 1906.
57. CLIFFORD RICHARDSON, 1907.

*Section D.—Mechanical Science and Engineering.*

31. W. P. TROWBRIDGE,* 1882.
32. DEVOLSON WOOD, 1883, absent, but place was not filled.
33. R. H. THURSTON,* 1884.
34. J BURKITT WEBB, 1885.
35 O. CHANUTE, 1886.
36. E. B. COXE, 1887.
37. C. J. H. WOODBURY, 1888.
38. JAMES E. DENTON, 1889.
39. JAMES E. DENTON, 1890, in place of A. BEARDSLEY, absent.
40. THOMAS GRAY, 1891.
41. J. B. JOHNSON, 1892.
42. S. W ROBINSON, 1893.
43. MANSFIELD MERRIMAN, 1894.
44. WILLIAM KENT, 1895.
45. FRANK O. MARVIN, 1896.
46 JOHN GALBRAITH, 1897.
47. JOHN GALBRAITH, 1898, in the absence of M.E.COOLEY.
48. STORM BULL, 1899.
49. JOHN A. BRASHEAR, 1900.
50. H. S. JACOBY, 1901.

VICE-PRESIDENTS OF SECTIONS, CONTINUED.

51. J. J. FLATHER, 1902.
52. CLARENCE A. WALDO, 1903.
53. C. M. WOODWARD, 1904.
54. C. M. WOODWARD, 1905, in the absence of D. S. JACOBUS.
55. F. W. MCNAIR, 1906.
56. W. R. WARNER, 1906.
57. W. R. WARNER, 1907.

*Section E.—Geology and Geography.*

31. E. T. COX, 1882.
32. C. H. HITCHCOCK, 1883.
33. N. H. WINCHELL, 1884.
34. EDWARD ORTON,* 1885.
35. T. C. CHAMBERLIN, 1886.
36. G. K. GILBERT, 1887.
37. GEORGE H. COOK,* 1888.
38. CHARLES A. WHITE, 1889.
39. JOHN C. BRANNER, 1890.
40. J. J. STEVENSON, 1891.
41. H. S. WILLIAMS, 1892.
42. CHARLES D. WALCOTT, 1893.
43. SAMUEL CALVIN, 1894.
44. JED HOTCHKISS, 1895.
45. B. K. EMERSON, 1896.
46. I. C. WHITE, 1897. E. W. CLAYPOLE,* 1897.
47. H. L. FAIRCHILD, 1898.
48. J. F. WHITEAVES, 1899
49. J. F. KEMP, 1900.
50. C. R. VAN HISE, 1901.
51. JOSEPH A. HOLMES, 1902, in the absence of O. A. DERBY
52. WM. M. DAVIS, 1903.
53. I. C. RUSSELL, 1904.
54. EUGENE A. SMITH, 1905.
55. WM. NORTH RICE, 1906.
56. A. C. LANE, 1906
57. A. C. LANE, 1907.

*Section F.—Biology*, 1882–1892.

31. W H. DALL, 1882.
32. W. J. BEAL, 1883.
33. E. D. COPE,* 1884.
34. T. J. BURRILL, 1885, in the absence of B. G. WILDER.
35. H. P. BOWDITCH, 1886.
36. W. G. FARLOW, 1887.
37. C. V. RILEY,* 1888.
38. GEORGE L. GOODALE, 1889.
39. C. S. MINOT, 1890.
40. J. M. COULTER, 1891.
41. S. H. GAGE, 1892.

*Section F.—Zoology.*

42. HENRY F. OSBORN, 1893.
43. J. A. LINTER,* 1894, in place of S. H. SCUDDER, res'd.
44. L. O. HOWARD, 1895, in place of D. S. JORDAN, res'd.
45. THEO. GILL, 1896.
46. L. O. HOWARD, 1897, in place of G. BROWN GOODE,* deceased.
47. A. S. PACKARD,* 1898.
48. S. H. GAGE, 1899.
49. C. B. DAVENPORT, 1900.
50. D. S. JORDAN, 1901.
51. E. L. MARK, 1902, in the absence of C. C. NUTTING.
52. C. W. HARGITT, 1903.
53. E. L. MARK, 1904.
54. C. HART MERRIAM, 1905.
55. H. B WARD, 1906.
56. E. G. CONKLIN, 1906.
57. E. G. CONKLIN, 1907.

*Section G.—Microscopy*, 1882–85.

31. A. H. TUTTLE, 1882.
32. J. D. COX, 1883.

VICE-PRESIDENTS OF THE SECTIONS, CONTINUED.

33. T. G. WORMLEY,* 1884.
34. S. H. GAGE, 1885.
(Section united with F in 1886.)

*Section G.—Botany.*

42. CHARLES E. BESSEY, 1893.
43. L. M. UNDERWOOD, 1894.
. E. BESSEY, 1894.
44. J. C. ARTHUR, 1895.
45. N. L. BRITTON, 1896.
46. G. F. ATKINSON, 1897.
47. W. G. FARLOW, 1898.
48. C. R. BARNES, 1899.
49. W. TRELEASE, 1900.
50. B. T. GALLOWAY, 1901.
51. C. E. BESSEY, 1902, in the absence of D. H. CAMPBELL.
52. F. V. COVILLE, 1903.
53. T. H. MACBRIDE, 1904.
54. B. L. ROBINSON, 1905.
55. B. L. ROBINSON, 1906, in the absence of ERWIN F. SMITH.
56. D. T. MACDOUGALL, 1906.
57. D. T. MACDOUGALL, 1907.

*Section H.—Anthropology.*

31. ALEX. WINCHELL,* 1882.
32. OTIS T. MASON, 1883.
33. EDWARD S. MORSE, 1884.
34. J. OWEN DORSEY,* 1885, in the absence of W. H. DALL.
35. HORATIO HALE,* 1886.
36. D. G. BRINTON,* 1887.
37. CHARLES C. ABBOTT, 1888.
38. GARRICK MALLERY,* 1889.
39. FRANK BAKER, 1890.
40. JOSEPH JASTROW, 1891.
41. W. H. HOLMES, 1892.
42. J. OWEN DORSEY,* 1893.
43. FRANZ BOAS, 1894.
44. F. H. CUSHING,* 1895.
45. ALICE C. FLETCHER, 1896.
46. W J MCGEE, 1897.
47. J. MCK. CATTELL, 1898.
48. THOMAS WILSON,* 1899.
49. A. W. BUTLER, 1900.
50. J. WALTER FEWKES, 1901.
51. STEWART CULIN, 1902.
52. GEO. A. DORSEY, 1903.
53. M. H. SAVILLE, 1904.
54. WALTER HOUGH, 1905.
55. GEORGE GRANT MCCURDY. 1906.
56. HUGO MUNSTERBERG, 1906.
57. A L. KROEBER, 1907.

*Section I.—Social and Economic Science.*

31. E. B. ELLIOTT,* 1882.
32. FRANKLIN B. HOUGH,*1883.
33. JOHN EATON,* 1884.
34. EDWARD ATKINSON, 1885.
35. JOSEPH CUMMINGS,* 1886.
36. H. E. ALVORD,* 1887.
37. CHARLES W. SMILEY, 1888.
38. CHARLES S. HILL, 1889.
39. J. RICHARDS DODGE, 1890
40. EDMUND J. JAMES, 1891.
41. L. F. WARD, 1892, in place of S. D. HORTON,* resigned.
42. WILLIAM H. BREWER, 1893.
43. HENRY FARQUHAR, 1894.
44. B. E. FERNOW, 1895.
45. W. L. LAZENBY, 1896.
46. R. T. COLBURN, 1897.
47. ARCHIBALD BLUE, 1898
48. MARCUS BENJAMIN, 1899.
49. MARCUS BENJAMIN, 1900, in the absence of C. M. WOODWARD.

VICE-PRESIDENTS OF THE SECTIONS, CONTINUED.

50. JOHN HYDE, 1901.
51. JOHN HYDE, 1902, in the absence of CARROLL D. WRIGHT.
52. H. T. NEWCOMB, 1903.
53. SIMEON E. BALDWIN, 1904.
54. MARTIN A. KNAPP, 1905.
55. IRVING FISHER, 1906.
56. CHAS. A. CONANT, 1906.
57. CHAS. A. CONANT, 1907.

*Section K.—Physiology and Experimental Medicine.*

51. W. H. WELCH, 1902.
52. W. H. WELCH, 1903.
53. H. P. BOWDITCH, 1904.
54. H. P. BOWDITCH, 1905.
55. ALEXANDER C. ABBOTT, 1906, in the absence of W. T. SEDGWICK.
56. SIMON FLEXNER, 1906.
57. SIMON FLEXNER, 1907.

*Section L.—Education.*

58. ELMER BROWN, 1908.

## SECRETARIES.

*General Secretaries*, 1848–

1. WALTER R. JOHNSON,* 1848.
2. E. N. HORSFORD,* 1849, in the absence of JEFFRIES WYMAN.*
3. L. R. GIBBS, 1850, in the absence of E. C. HERRICK.*
4. E. C. HERRICK,* 1850.
5. WM. B. ROGERS,* 1851, in the absence of E. C. HERRICK.*
6. WM. B. ROGERS,* 1851.
7. S. ST. JOHN,* 1853, in the absence of J. D. DANA.*
8. J. LAWRENCE SMITH,* 1854.
9. WOLCOTT GIBBS, 1855.
10. B. A. GOULD,* 1856.
11. JOHN L. LECONTE,* 1857.
12. W.M.GILLESPIE,*1858,in the absence of WM.CHAUVENET.*
13. WM. CHAUVENET,* 1859.
14. JOSEPH LECONTE,* 1860.
15. ELIAS LOOMIS,* 1866, in the absence of W. P. TROWBRIDGE.*
16. C. S. LYMAN,* 1867.
17. SIMON NEWCOMB, 1868, in the absence of A.P.ROCKWELL.
18. O. C. MARSH,* 1869.
19. F. W. PUTNAM, 1870, in the absence of C. F. HARTT.*
20. F. W. PUTNAM, 1871.
21. EDWARD S. MORSE, 1872.
22. C. A. WHITE, 1873.
23. A. C. HAMLIN, 1874.
24. S. H. SCUDDER, 1875.
25. T. C. MENDENHALL, 1876.
26. AUG. R. GROTE, 1877.
27. H. C. BOLTON,* 1878.
28. H. C. BOLTON,* 1879, in the absence of GEORGE LITTLE.
29. J. K. REES, 1880.
30. C. V. RILEY,* 1881.
31. WILLIAM SAUNDERS, 1882.
32. J. R. EASTMAN, 1883.
33. ALFRED SPRINGER, 1884.
34. C. S. MINOT, 1885.
35. S. G. WILLIAMS,* 1886.
36. WILLIAM H. PETTEE, 1887.
37. JULIUS POHLMAN, 1888.
38. C. LEO MEES, 1889.

SECRETARIES, CONTINUED.

39. H. C. BOLTON,* 1890.
40. H. W. WILEY, 1891.
41. A. W. BUTLER, 1892.
42. T. H. NORTON, 1893.
43. H. L. FAIRCHILD, 1894.
44. JAS. LEWIS HOWE, 1895.
45. CHARLES R. BARNES, 1896.
46. ASAPH HALL, JR., 1897.
47. J. MCMAHON, 1898, in place of D.S. KELLICOTT,* deceased.
48. F. BEDELL, 1899.
49. CHAS. BASKERVILLE, 1900.
50. JOHN M. COULTER, 1901, in the absence of WILLIAM HALLOCK.
51. D. T. MACDOUGAL, 1902.
52. HENRY B. WARD, 1903.
53. C. W. STILES, 1904.
54. CHARLES S. HOWE, 1905.
55. C. A. WALDO, 1906.
56. JOHN F. HAYFORD, 1906.
57. JOHN F. HAYFORD, 1907.

*Permanent Secretaries*, 1851–

5–7. SPENCER F. BAIRD,* 1851–4
8–17. JOSEPH LOVERING,* 1854. –68.
18. F. W. PUTNAM, 1869, in the absence of J. LOVERING.*
19–21. JOSEPH LOVERING,* 1870 –73.
22–46. F. W. PUTNAM, 1873–98.
47–54. L. O. HOWARD, 1898–05.
55–60. L. O. HOWARD, 1906–10.

*Assistant General Secretaries*, 1882–1887.

31. J. R. EASTMAN, 1882.
32. ALFRED SPRINGER, 1883.
33. C. S. MINOT, 1884, in the absence of E. S. HOLDEN.
34. S. G. WILLIAMS,* 1885, in the absence of C. C. ABBOTT
35. W. H. PETTEE, 1886.
36. J. C. ARTHUR, 1887.

*Secretaries of the Council*, 1888–

37. C. LEO MEES, 1888.
38. H. C. BOLTON,* 1889.
39. H. W. WILEY, 1890.
40. A. W. BUTLER, 1891.
41. T. H. NORTON, 1892.
42. H. LEROY FAIRCHILD, 1893.
43. JAS. LEWIS HOWE, 1894.
44. CHARLES R. BARNES, 1895.
45. ASAPH HALL, JR., 1896.
46. D. S. KELLICOTT,* 1897.
47. FREDERICK BEDELL, 1898.
48. CHARLES BASKERVILLE, 1899.
49. WILLIAM HALLOCK, 1900.
50. D. T. MACDOUGAL, 1901.
51. H. B. WARD, 1902.
52. CH. WARDELL STILES, 1903.
53. CHAS. S. HOWE, 1904.
54. C. A. WALDO, 1905.
55. JOHN T. HAYFORD, 1906.
56. F. W. MCNAIR, 1906.
57 F. W. MCNAIR, 1907.

*Secretaries of Section A.—Mathematics, Physics and Chemistry*, 1875–1881.

24. { S. P. LANGLEY,* 1875. T. C. MENDENHALL, 1875.
25. A. W. WRIGHT, 1876.
26. H. C. BOLTON,* 1877.
27. F. E. NIPHER, 1878.
28. J. K. REES, 1879.
29. H. B. MASON, 1880.

## SECRETARIES, CONTINUED.

30. E.T.TAPPAN, 1881, in the absence of JNO. TROWBRIDGE.

*Secretaries of Section B.—Natural History*, 1874–1881.

24. EDWARD S. MORSE, 1875.
25. ALBERT H. TUTTLE, 1876.
26. WILLIAM H. DALL, 1877.
27. GEORGE LITTLE, 1878.
28. WM. H. DALL, 1879, in the absence of A. C. WETHERBY.
29. CHARLES V. RILEY,* 1880.
30. WILLIAM SAUNDERS, 1881.

## SECRETARIES OF SUBSECTIONS, 1875–1881.

*Subsection of Chemistry.*

24. F. W. CLARKE, 1875.
25. H. C. BOLTON,* 1876.
26. P. SCHWEITZER, 1877.
27. A. P. S. STUART, 1878.
28. W. R. NICHOLS,* 1879.
29. C. E. MUNROE, 1880.
30. ALFRED SPRINGER, 1881, in the absence of R.B.WARDER.

*Subsection of Entomology.*

30. B. P. MANN, 1881.

*Subsection of Anthropology.*

24. F. W. PUTNAM, 1875.
25. OTIS T. MASON, 1876.
26, 27. United with Section B.
28, 29, 30. J. G. HENDERSON, 1879–81.

*Subsection of Microscopy.*

25. E. W. MORLEY, 1876.
26. T. O. SOMMERS, JR., 1877.
27. G. J. ENGELMANN, 1878.
28, 29. A. B. HERVEY, 1879–80.
30. W. H. SEAMAN, 1881, in the absence of S. P. SHARPLES.

## SECRETARIES OF THE SECTIONS, 1882–

*Section A.—Mathematics and Astronomy.*

31. H. T. EDDY, 1882.
32. G. W. HOUGH, 1883, in the absence of W. W. JOHNSON.
33. G. W. HOUGH, 1884.
34. E. W. HYDE, 1885.
35. S. C. CHANDLER, 1886.
36. H. M. PAUL, 1887.
37. C. C. DOOLITTLE, 1888.
38. G. C. COMSTOCK, 1889.
39. W. W. BEMAN, 1890.
40. F. H. BIGELOW, 1891.
41. WINSLOW UPTON, 1892.
42. C. A. WALDO, 1893, in the absence of A. W. PHILLIPS.
43. J. C. KERSHNER, 1894, in place of W.W.BEMAN, res'd.
44. ASAPH HALL, JR., 1895, in place of E. H. MOORE, res'd.
45. EDWIN B. FROST, 1896.
46. JAMES MCMAHON, 1897.
47. WINSLOW UPTON, 1898, in place of ALEX. ZIWET, resigned.
48. JOHN F. HAYFORD, 1899.
49. W. M. STRONG, 1900.

50. G. A. MILLER, 1901, in place of H. C. LORD, resigned.
51. E. S. CRAWLEY, 1902.
52. C. S. HOWE, 1903.
53–57. L. G. WELD, 1904–1907.

*Section B.—Physics.*

31. C. S. HASTINGS, 1882.
32. F. E. NIPHER, 1883, in the absence of C. K. WEAD.
33. N. D. C. HODGES, 1884.
34. B. F. THOMAS, 1885, in place of A. A. MICHELSON, resigned.
35. H. S. CARHART, 1886.
36. C. LEO MEES, 1887.
37. ALEX. MACFARLANE, 1888.
38. E. L. NICHOLS, 1889.
39. E. M. AVERY, 1890.
40. ALEX. MACFARLANE, 1891.
41. BROWN AYRES, 1892.
42. W. LECONTE STEVENS, 1893.
43. B. W. SNOW, 1894.
44. E. MERRITT, 1895.
45. FRANK P. WHITMAN, 1896.
46. FREDERICK BEDELL, 1897.
47. W. S. FRANKLIN, 1898, in place of E. B. ROSA, resigned.
48. WILLIAM HALLOCK, 1899.
49. R. A. FESSENDEN, 1900.
50. JOHN ZELENY, 1901, in place of J. O. REED, resigned.
51. E. F. NICHOLS, 1902.
52. D. C. MILLER, 1903.
53–57. D. C. MILLER, 1904–1907.

*Section C.—Chemistry.*

31. ALFRED SPRINGER, 1882.
32. { J. W. LANGLEY, 1883. / W. MCMURTRIE, 1883.
33. H. CARMICHAEL, 1884, in the absence of R. B. WARDER.
34. F. P. DUNNINGTON, 1885.
35. W. MCMURTRIE, 1886.
36. C. F. MABERY, 1887.
37. W. L. DUDLEY, 1888.
38. EDWARD HART, 1889.
39. W. A. NOYES, 1890.
40. T. H. NORTON, 1891.
41. JAS. LEWIS HOWE, 1892.
42. H. N. STOKES, 1893, in the absence of J. U. NEF.
43. MORRIS LOEB, 1894, in place of S. M. BABCOCK, resigned.
44. { W. P. MASON, 1895. / W. O. ATWATER, 1895.
45. FRANK P. VENABLE, 1896.
46. P. C. FREER, 1897.
47. C. BASKERVILLE, 1898.
48. H. A. WEBER, 1899.
49. A. A. NOYES, 1900.
50. W. MCPHERSON, 1901.
51. F. C. PHILLIPS, 1902.
52. H. N. STOKES, 1903.
53–58. CHAS. L. PARSONS, 1904–1908.

*Section D.—Mechanical Science and Engineering.*

31. J. BURKITT WEBB, 1882, in the absence of C. B. DUDLEY.
32. J. BURKITT WEBB, 1883, *pro tempore.*
33. J. BURKITT WEBB, 1884.
34. C. J. H. WOODBURY, 1885.
35. WILLIAM KENT, 1886.
36. G. M. BOND, 1887.
37. ARTHUR BEARDSLEY, 1888.
38. W. B. WARNER, 1889.
39. THOMAS GRAY, 1890.
40. WILLIAM KENT, 1891.
41. O. H. LANDRETH, 1892.
42. D. S. JACOBUS, 1893.

SECRETARIES OF THE SECTIONS, CONTINUED.

43. JOHN H. KINEALY, 1894.
44. H. S. JACOBY, 1895.
45. JOHN GALBRAITH, 1896.
46. JOHN J. FLATHER, 1897.
47. JOHN J. FLATHER, 1898, in the absence of W. S. ALDRICH.
48. J. M. PORTER, 1899.
49. W. T. MAGRUDER, 1900.
50. C. W. COMSTOCK, 1901, in the absence of W. H. JAQUES.
51. C. A. WALDO, 1902.
52. ELWOOD MEAD, 1903, in the absence of ALBERT KINGSBURY.
53–58. W. T. MAGRUDER, 1904–1908.

*Section E.—Geology and Geography.*

31. H. S. WILLIAMS, 1882, in the absence of C. E. DUTTON.
32. A. A. JULIEN, 1883.
33. E. A. SMITH, 1884.
34. G. K. GILBERT, 1885, in the absence of H. C. LEWIS.*
35. E. W. CLAYPOLE,* 1836.
36. W. M. DAVIS, 1887, in the absence of T. B. COMSTOCK.
37. JOHN C. BRANNER, 1888.
38. JOHN C. BRANNER, 1889.
39. SAMUEL CALVIN, 1890.
40. W J MCGEE, 1891.
41. R. D. SALISBURY, 1892.
42. W. H. HOBBS,* 1893, in place of R. T. HILL, resigned.
43. JED. HOTCHKISS,* 1894, in place of W. M. DAVIS, res'd.
44. J. PERRIN SMITH, 1895.
45. W. N. RICE, 1896, in place of A. C. GILL, resigned.
46. C. H. SMITH, JR., 1897.
47. WARREN UPHAM, 1898.
48. ARTHUR HOLLICK, 1899.
49. J. A. HOLMES, 1900.
50. H. B. PATTON, 1901, in the absence of R. A. F. PENROSE.
51. F. P. GULLIVER, 1902.
52. E. O. HOVEY, 1903.
53. G. B. SHATTUCK, 1904.
54–57. EDMUND O. HOVEY, 1905–1907.

*Section F.—Biology, 1882–1892*

31. WILLIAM OSLER, 1882, in the absence of C. S. MINOT.
32. S. A. FORBES, 1883.
33. C. E. BESSEY, 1884.
34. J. A. LINTNER,* 1885, in place of C. H. FERNALD, res'd.
35. J. C. ARTHUR, 1886.
36. J. H. COMSTOCK, 1887.
37. B. E. FERNOW, 1888.
38. A. W. BUTLER, 1889.
39. J. M. COULTER, 1890.
40. A. J. COOK, 1891.
41. D. B. HALSTEAD, 1892.

*Section F.—Zoology.*

42. L. O. HOWARD, 1893.
43. JOHN B. SMITH, 1894, in place of WM. LIBBY, JR., resigned.
44. C. W. HARGITT, 1895, in place of S. A. FORBES, res'd.
45. D. S. KELLICOTT,* 1896.
46. C. C. NUTTING, 1897.
47. R. T. JACKSON, 1898, in place of C. W. STILES, resigned.
48. C. L. MARLATT, 1899, in place of F. W. TRUE, resigned.

SECRETARIES OF THE SECTIONS, CONTINUED.

49. C. H. EIGENMANN, 1900.
50. H. B. WARD, 1901.
51. C. W. STILES, 1902.
52. C. J. HERRICK, 1903.
53–58. C. J. HERRICK, 1904–08.

*Section G.—Microscopy*, 1882–85.

31. ROBERT BROWN, JR., 1882.
32. CARL SEILER, 1883.
33. ROMYN HITCHCOCK, 1884.
34. W. H. WALMSLEY, 1885.

*Section G.—Botany.*

42. B. T. GALLOWAY, 1893, in the absence of F. V. COVILLE.
43. CHAS. R. BARNES, 1894.
44. { B. T. GALLOWAY, 1895. / M. B. WAITE, 1895.
45. GEORGE F. ATKINSON, 1896.
46. F. C. NEWCOMBE, 1897.
47. ERWIN F. SMITH, 1898.
48. W. A. KELLERMAN, 1899.
49. D. T. MACDOUGAL, 1900.
50. ERNST A. BESSEY, 1901, in the absence of A. S. HITCHCOCK.
51. H. VON SCHRENK, 1902.
52. C. J. CHAMBERLAIN, 1903.
53–55. F. E. LLOYD, 1904–1906.
56. G. F. ATKINSON, 1906, in the absence of F. E. LLOYD.
57 TRACY E. HAZEN, 1907, in the absence of F. E. LLOYD.

*Section H.—Anthropology.*

31. OTIS T. MASON, 1882.
32. G. H. PERKINS, 1883.
33. G. H. PERKINS, 1884, in the absence of W. H. HOLMES.
34. ERMINNIE A. SMITH,* 1885.
35. A. W. BUTLER, 1886.
36. CHAS. C. ABBOTT, 1887, in the absence of F. W. LANGDON.
37. FRANK BAKER, 1888.
38. W. M. BEAUCHAMP, 1889.
39. JOSEPH JASTROW, 1890.
40. W. H. HOLMES, 1891.
41. W. M. BEAUCHAMP, 1892, in place of S. CULIN, resigned.
42. W. K. MOOREHEAD, 1893.
43. A. F. CHAMBERLIN, 1894.
44. { STEWART CULIN and W. W. TOOKER, 1895, in place of ANITA N. MCGEE, res'd.
45. G. H. PERKINS, 1896, in place of J. G. BOURKE,* dec'd.
46. ANITA N. MCGEE, 1897, in place of HARLAN I. SMITH, res'd.
47. MARSHALL H. SAVILLE, 1898.
48. E. W. SCRIPTURE, 1899, in place of GEO. A. DORSEY, resigned.
49. FRANK RUSSELL,* 1900.
50. G. G. MACCURDY, 1901.
51. HARLAN I. SMITH, 1902.
52. R. B. DIXON, 1903.
53–58. GEO. H. PEPPER, 04–08.

*Section I.—Social and Economic Science.*

31. { FRANKLIN B. HOUGH,* 1882. / J. RICHARDS DODGE, 1882.
32. JOSEPH CUMMINGS,* 1883.
33. CHARLES W. SMILEY, 1884.
34. CHAS. W. SMILEY, 1885, in the absence of J. W. CHICKERING.

SECRETARIES OF THE SECTIONS, CONTINUED.

35. H. E. ALVORD,* 1886.
36. W. R. LAZENBY, 1887.
37. CHARLES S. HILL, 1888.
38. J. RICHARDS DODGE, 1889.
39. B. E. FERNOW, 1890.
40. B. E. FERNOW, 1891.
41. HENRY FARQUHAR, 1892, in place of L. F. WARD, made Vice-President.
42. NELLIE S. KEDZIE, 1893.
43. MANLEY MILES, 1894.
44. W. R. LAZENBY, 1895, in place of E. A. ROSS, resigned.
45. R. T. COLBURN, 1896.
46. ARCHIBALD BLUE, 1897.
47. MARCUS BENJAMIN, 1898.
48. CALVIN M. WOODWARD, 1899.
49. H. T. NEWCOMB, 1900.
50. R. A. PEARSON, 1901, in place of CORA A. BENNESON, res'd.
51. F. R. RUTTER, 1902, in place of WALTER F. WILLCOX, resigned.
52. F. H. HITCHCOCK, 1903.
53–57. J. F. CROWELL, 1904–07.

*Section K.—Physiology and Experimental Medicine.*

51. F. S. LEE, 1902.
52. F. S. LEE, 1903.
53. F. S. LEE, 1904.
54–58. W. J. GIES, 1905–08.

*Section L.—Education.*

58. E. L. THORNDIKE, 1908.

## TREASURERS.

1. JEFFRIES WYMAN,* 1848.
2. A. L. ELWYN,* 1849.
3. ST. J. RAVENEL,* 1850, in the absence of A. L. ELWYN.*
4. A. L. ELWYN,* 1850.
5. SPENCER F. BAIRD,* 1851, in the absence of A. L. ELWYN.*
6–7. A. L. ELWYN,* 1851–53.
8. J. L. LECONTE,* 1854, in the absence of A. L. ELWYN.*
9–19. A. L. ELWYN,* 1855–1870.
20–30. WM. S. VAUX,* 1871–1881.
32–42. WM. LILLY,* 1882–93.
43–49. R. S. WOODWARD, 1894–1900.
50–54. R. S. WOODWARD, 1901–1905.
55–60. R. S. WOODWARD, 1906–1910.

# Commonwealth of Massachusetts.

## In the Year One Thousand Eight Hundred and Seventy-Four.

AN ACT

TO INCORPORATE THE "AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE."

*Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:*

SECTION 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge, and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding, and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

SECTION 2. Said corporation may have and hold by purchase, grant, gift, or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

SECTION 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

SECTION 4. This act shall take effect upon its passage.

HOUSE OF REPRESENTATIVES, March 10, 1874.
Passed to be enacted,
JOHN E. SANFORD, *Speaker.*

IN SENATE, March 17, 1874.
Passed to be enacted, March 19, 1874.
GEO. B. LORING, *President.* Approved.
W. B. WASHBURN.

SECRETARY'S DEPARTMENT,
Boston, April 3, 1874.
A true copy, Attest:
DAVID PULSIFER,
*Deputy Secretary of the Commonwealth.*

# CONSTITUTION

OF THE

# AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

**Incorporated by Act of the General Court of the Commonwealth of Massachusetts**

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## Objects.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

## Membership.

ART. 2. The Association shall consist of members, fellows, patrons, corresponding members and honorary fellows.

## Members.

ART. 3. Any person may become a member of the Association upon recommendation in writing by two members or fellows, and election by the Council. Any incorporated scientific society or institution, or any public or incorporated library, may be enrolled as a member of the Association by vote of the Council by payment of the initiation fee; such society, institution, or library may be represented by either the President, Curator, Director, or Librarian presenting proper credentials at any meeting of the Association for which the assessment has been paid.

## Associates.

Associates for any single meeting shall be admitted on the payment of three dollars, such associates to have all the privileges of the meeting, except reading papers and voting.

Members of scientific societies whose meetings are contemporaneous with, or immediately subsequent to, that of the Associa-

tion, and which are recognized by vote of the Council as "Affiliated Societies," may become associate members for that meeting on the payment of three dollars. They shall be entitled to all the privileges of membership except voting or appointment to office, but their names shall not appear in the list of members printed in the annual report.

### Foreign Associates.

Any member or fellow of any national scientific or educational institution, or of any society or academy of science, of any country not in America, who may be present at any meeting of the Association shall, on presenting the proper credentials, be enrolled without fee as a Foreign Associate, and shall be entitled to all the privileges of the meeting except voting on matters of business.

### Fellows.

Art. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have, by their labors, aided in advancing science. The election of fellows shall be by ballot, and a majority vote of the members of the Council at a designated meeting of the Council.

### Patrons.

Art. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a patron, and shall be entitled to all the privileges of a member and to all its publications.

### Honorary Fellows and Corresponding Members.

Art. 6. Honorary fellows of the Association, not exceeding three for each Section, may be elected, the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary fellows shall be entitled to all the privileges of fellows, and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election. Corresponding members shall consist of such scientists not residing in America as may be elected by the Council, and their number shall be limited to fifty. Corresponding members shall be entitled to

all the privileges of members and to the annual volumes of Proceedings published subsequent to their election.

### SUSPENSIONS.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided, that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been re-elected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

### OFFICERS.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

ART. 9. The officers of the Association shall be elected by ballot by the General Committee from the fellows, and shall consist of a President, a Vice-President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, the Treasurer, and the Secretaries of the Sections, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be re-eligible for the next two meetings. The term of office of the Permanent Secretary, of the Treasurer, and of the Secretaries of the Sections, shall be five years.

### PRESIDENT.

ART. 10. The President, or, in his absence, the senior Vice-President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

### VICE-PRESIDENTS.

ART. 11. The Vice-Presidents shall be chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own Section, at such time as the Council shall determine at the meeting subsequent to that at which he presides. The Vice-Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice-Presidents shall have seniority in order of their continuous membership in the Association.

### GENERAL SECRETARY.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

### SECRETARY OF THE COUNCIL.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

### PERMANENT SECRETARY.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the

Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets, and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the intervals between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

### Treasurer.

Art. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council. The Treasurer shall give bonds for the faithful performance of his duty in such manner and sum as the Council shall from time to time direct.

### Secretaries of the Sections.

Art. 16. The Secretaries of the Sections shall keep the records of their respective Sections, and, at the close of the meeting, give

the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the sectional committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

### VACANCIES.

ART. 17. In case of a vacancy in the office of President, the senior Vice-President shall preside, as provided in Article 10, until the General Committee can be assembled and the vacancy filled by election. Vacancies in the offices of Vice-President, Permanent Secretary, Secretary of the Council, Secretaries of the Sections, and Treasurer, shall be filled by the Council by ballot.

### COUNCIL.

ART. 18. The Council shall consist of the Past Presidents, and the Vice-Presidents of the last two meetings, together with the President, the Vice-Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, of one fellow elected from each Section by ballot on the first day of its meeting, of one fellow elected by each affiliated society, and one additional fellow from each affiliated society having more than twenty-five members who are fellows of the Association, and of nine fellows elected by the Council, three being annually elected for a term of three years. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the program for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the Council room at 9 o'clock A. M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall decide

which papers, discussions, and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programs for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following subcommittees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

### General Committee.

ART. 19. The General Committee shall consist of the Council and one member or fellow elected by each of the Sections, who shall serve until their successors are elected. It shall be the duty of the committee to meet at the call of the President and elect the general officers for the following meeting of the Association. It shall alsobe the duty of this committee to fix the time and place for the next meeting. The Vice-President and Secretary of each Section shall be recommended to the General Committee by the Sectional Committee.

### Meetings.

ART. 20. The Association shall hold a public meeting annually for one week or longer, at such time and place as may be determined by vote of the General Committee, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

But if suitable preliminary arrangements cannot be made, the Council may afterward change the time and place appointed by the General Committee, if such change is believed advisable, by two-thirds of the members present.

ART. 21. A General Session shall be held at 10 o'clock, A. M. on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry; including its application to Agriculture and the Arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Zoology;* G, *Botany;* H, *Anthropology and Psychology;* I, *Social and Economic Science;* K, *Physiology and Experimental Medicine,* L, *Education.* The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice-President and Secretary of the Sections comprising it.

SECTIONAL COMMITTEES.

ART. 23. Immediately on the organization of a Section there shall be a member or fellow elected by ballot after open nomination, who, with the Vice-President and Secretary and the Vice-President and Secretary of the preceding meeting, and the members or fellows elected by ballot at the four preceding meetings, shall form its Sectional Committee. The Sectional Committee shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session. The Sectional Committee may invite distinguished foreign associates present at any meeting to serve as honorary members of said Committee.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the section.

ART. 25. No paper shall be read in any Section or Subsections until it has been placed on the program of the day by the Sectional Committee.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the

daily programs and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programs except such as have passed the Committee. No change shall be made in the program for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the program; but every such title, with the abstract of the paper or the paper itself, must be referred to the Council with the reasons why it was refused. The Sectional Committee shall also make nominations to the General Committee for Vice-President and Secretary of their respective Sections as provided for in Article 19.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the Sections, and they shall not place on the program any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

### PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Secretary of the proper Section or to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be considered by a Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready when called upon, in the regular order of the official program, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable the proceedings and discussions at General Sessions, Sections and Subsections, shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

### PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

### LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

### LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and

pamphlets, which shall be delivered to them at their expense on their giving a receipt agreeing to make good any loss or damage, and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council. [The Library of the Association was, by vote of the Council in 1895, placed on deposit in the Library of the University of Cincinnati, Ohio. Members can obtain the use of books by writing to the Librarian of the University Library, Cincinnati, Ohio.]

### Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual dues.

Art. 35. The annual dues for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member, and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association, but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

Art. 37. All fees and dues must be paid to the Permanent Secretary who shall give proper receipts for the same.

### Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually by Auditors appointed by the Council.

### Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

# MEMBERS AND FELLOWS

OF THE

# AMERICAN ASSOCIATION

FOR THE

## ADVANCEMENT OF SCIENCE.

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### SURVIVING FOUNDERS.

[At the Brooklyn Meeting, 1894, a resolution was unanimously adopted by which all the surviving founders of the Association who have maintained an interest in science were made Honorary Life Members of the Association in recognition of their pioneer work in American Science.]

BOYÉ, MARTIN H., Coopersburg, Pa.
GIBBS, WOLCOTT, Newport, R. I.

### PATRONS.

[Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications. The names of Patrons are to remain permanently on the list.]

THOMPSON, MRS ELIZABETH, Stamford, Conn. (22). (Died July, 1899.)
LILLY, GEN. WILLIAM, Mauch Chunk, Pa. (28). (Died Dec. 1, 1893.)
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).
MCMILLIN, EMERSON, 40 Wall St., New York, N. Y. (37).

### HONORARY FELLOWS.

[See ARTICLE VI of the Constitution.]

*GIBBS, PROF. WOLCOTT, Newport, R. I. (1). 1896. **B C**
*WARINGTON, ROBERT, F. R. S., Rothamsted, Harpenden, England. (40). 1899. **C**
*WESTINGHOUSE, GEORGE, Pittsburg, Pa. (50). 1902. **D**

## MEMBERS AND FELLOWS.

The names designated by an asterisk (*) are those of Fellows. (See ARTICLE IV of the Constitution.) The number in parenthesis indicates the meeting at which the Member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the Sections to which the Member or Fellow belongs. When the name is given in small capitals, it designates that the Member or Fellow is also a Life Member. Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a life membership is used for the general purposes of the Association during the life of the Member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the publications. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

The Constitution requires that the names of all Members two years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the publications of the Association, including the journal *Science*.

*Abbe, Cleveland, Professor of Meteorology, Weather Bureau, U. S. Dept. Agriculture, Washington, D. C. (16). 1874. **AB**

*Abbe, Cleveland, Jr., Mt. Weather, Bluemont, Va. (44). 1899. **E**

*Abbe, Dr. Robert, 13 W. 50th St., New York, N. Y. (36). 1892.

*Abbot, Charles G., Smithsonian Institution, Washington, D. C. (49). 1902. **B**

Abbot, E. Stanley, M. D., First Assistant Physician, McLean Hospital, Waverley, Mass. (54). **K**

*Abbott, Alexander C., Univ. of Penna., Philadelphia, Pa. (52). 1905. **K**

Abbott, Frank L., Professor of Physical Science, State Normal School, Greeley, Colo. (50). **BE**

Abbott, Theodore Sperry, C. E., Saltillo, Coahuila, Mexico. (52). **D**

*Abel, John J., Professor of Pharmacology, Johns Hopkins University, Baltimore, Md. (51). 1902. **C K**

Abraham, Abraham, care of Abraham & Straus, Brooklyn, N. Y. (43).

Abrams, LeRoy, Asst. Prof. Botany, Stanford University, Cal. (54). **G**

*Acheson, Edward Goodrich, President of the International Acheson Graphite Co., Niagara Falls, N. Y. (50). 1903. **C**

*Adams, Charles C., Zoology Building, Univ. of Chicago, Chicago, Ill. (50). 1903. **F**

Adams, C. F., Entomologist, Univ. Arkansas, Fayetteville, Ark. (54). **F**

*Adams, Charles Francis, Head of Science Department, Central High School, Detroit, Mich. (53). 1906. **B**

Adams, Comfort A., Prof. Electrical Engineering, Harvard Univ., Cambridge, Mass. (47). **B**

*Adams, Cyrus C., 25 Arden Place, Yonkers, N. Y. (54). 1906. **E**

Adams, Edward Dean, 1414–15 Empire Bldg., New York, N. Y. (49).

Adams, Frederick C., Mechanic Arts High School, Boston, Mass. (50). **BC**

Adams, John W., Prof. of Physics, McKinley Manual Training School, Washington, D. C. (54). B G

Adams, Mary W., 477 Prospect St., New Haven, Conn. (57). E

Adams, Matthew Prior, Instructor in Physics and Chemistry, State Normal School, New Britain, Conn. (54). B C

Adams, Maxwell, Prof. Chemistry, Nevada State University, Reno, Nevada. (57). C

*Adler, Cyrus, Smithsonian Institution, Washington, D. C. (54). 1906. H

*Adler, Felix, M. D., 123 E. 60th St., New York, N. Y. (54). 1906. K

*Adler, Isaac, M. D., 22 E. 62d St., New York, N. Y. (49). 1903. K

Adler, Leon N., Ph. D., Manufacturing Chemist, 100 William St., New York, N. Y. (56). C

*Adriance, John S., 105 E. 39th St., New York, N. Y. (39). 1895. C

Agnew, Paul G., Bureau of Standards, Washington, D. C. (54). B

*Aguilera, José G., Director of the Geological Institute of Mexico, 5ª Cipres, No. 2728, Mexico City, D. F. (53). 1905. E

Ahern, M. J., S J., Universitatstrasse 8, Innsbruck, Tyrol, Austria. (57). E

Aikin, Joseph M., M. D., Professor of Mental Diseases, Univ. of Nebraska College of Medicine, Omaha, Neb. (55). K

Ailes, Hon. Milton E., Riggs National Bank, Washington, D. C. (52). I

Ainsworth, Herman Reeve, M. D., Addison, N. Y. (51). I K

*Aitken, Robert G., Lick Observatory, Mt. Hamilton, Cal. (53). 1906. A

Akeley, Lewis E., Professor of Physics and Chemistry, University of South Dakota, Vermillion, S. Dak. (51). B C

Albert, Harry Lee, Professor of Biology, State Normal School, Cape Girardeau, Mo. (53). F G

Albert, Henry, M. D., Iowa State Univ. College of Medicine, Iowa City, Iowa. (57). K

Albrecht, Emil Poole, Secretary of The Bourse, 1523 N. 17th St., Philadelphia, Pa. (51). A D

*Albrecht, Sebastian, Lick Observatory, Mt. Hamilton, Cal. (53). 1906. A

Albree, Chester B., Mechanical Engineer, 1115 Market St., Allegheny, Pa. (50). D

*Alden, John, Pacific Mills, Lawrence, Mass. (36). 1898. C

*Alderson, Victor C., President Colorado School of Mines, Golden, Colorado. (50). 1903. D

*Aldrich, Truman Heminway, 1739 P St. N.W., Washington, D. C. (54). 1906. E

*Aldrich, Wm. S., Director, Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. (43). 1897. D

Alexander, Harry E. E., M. E., 18 and 20 W. 34th St., New York, N. Y. (50). D

Alexander, W. T , M. D., 940 St. Nicholas St., New York, N. Y. (57). K

Alexander, Daniel Basil William, 1020 Date St , Los Angelos, Cal (57). C

*Aley, Robert J., Ph. D., Indiana Univ., Bloomington, Ind. (49). 1906. A

Allderdice, Wm. H., Commander U. S. Navy, Navy Dept., Washington, D. C. (33). D

Alleman, Gellert, Ph. D., Swarthmore College, Swarthmore, Pa. (50). C

*Allen, Bennet Mills, Instructor in Anatomy, University of Wisconsin, Madison, Wis. (54). 1906. F K

Allen, Charles Elmer, 810 W. Johnson St., Madison, Wis. (55). G

Allen, C. H., 1 West 72d St., New York, N. Y. (57).

Allen, Charles Metcalf, Assistant Prof. of Experimental Engineering, Worcester Polytechnic Institute, Worcester, Mass. (52). D

Allen, David R., Associate Professor of Mathematics, University of Utah, Salt Lake City, Utah. (57). A

Allen, Edwin West, Editor of *Experiment Station Record*, U. S. Dept. Agriculture, Washington, D. C. (52).

*Allen, Frank, Ph. D., Professor of Physics, Univ. of Manitoba, Winnipeg, Manitoba. (49). 1903. B

Allen, H. Jerome, M. D., Colorado Bldg., Washington, D. C. (51). K

Allen, James Lane, 66 Fifth Ave, New York, N. Y. (57) I

Allen, Lyman Richards, Instructor in Geography and History, State Normal School, North Adams, Mass. (54). E

Allen, Richard H., Chatham, N. J. (49).

Allen, William Frederick, M. S., 180 Scotland Road, South Orange, N. J. (55).

Aller, Henry D., Supt. and Director U. S. Fisheries Laboratory, Beaufort, N. C. (57). F

*Allis, Edward Phelps, Jr., Palais de Carnolès, Menton, France. (52). 1905. F

*Allison, Andrew, Ellisville, Miss. (54). 1906. F G

*Allison, C. Edward, M. D., Elysburg, Pa. (51). 1906. K

Allison, William B., 1320 St. Charles Ave., New Orleans, La. (55). G

Almy, Frank Fayette, Professor Physics, Iowa College, Grinnell, Iowa. (57). **B**

*Almy, John E., Ph. D., Instructor in Physics, University of Nebraska, Lincoln, Neb. (50). 1901. **B**

Alpers, Martin E., Jr., 94 Randolph Ave., Dover, N. J. (57) **K**

Alsberg, Carl Lucas, Dept. Biological Chemistry, Harvard Medical School, Boston, Mass. (55). **C**

Alsop, E. B., 1502 20th St., N. W., Washington, D. C. (50). **D**

Alspach, E. F., 455 West Sixth Ave., Columbus, O. (48). **H**

Altamirano, Dr. Fernando, Instituto Medico Nacional, Esquina de Balderas y Ayuntamiento num 1202, Mexico, D. F. (53). **G**

Alwine, John, Jr., Associate Manager Baltimore Chrome Works, 1348 Block St., Baltimore, Md. (54). **C**

*Alwood, Wm. B., Charlottesville, Va. (39). 1891. **F**

*Ames, Oakes, Assistant Director of the Botanic Garden of Harvard University, North Easton, Mass. (50). 1905. **G**

*Ami, H. M., Geological Survey of Canada, Ottawa, Ontario, Canada. (54) 1906. **E**

Anders, Howard S., M. D., 1836 Wallace St., Philadelphia, Pa. (51). **K**

Anderson, A. J. C., 127 Water St., New York, N. Y. (49).

*Anderson, Alexander P., 5463 Washington Ave., Chicago, Ill. (45). 1899. **G**

Anderson, Douglas S., Professor Electrical Engineering, Tulane Univ., New Orleans, La. (49). **B D**

*Anderson, Frank, Mining Engineer, 1 Henry Flats, Salt Lake City, Utah. (50). 1906. **D E**

Anderson, Frank P., Epworth Seminary, Epworth, Iowa. (46).

Anderson, Robt. Van Vleck, U. S. Geological Survey, Washington, D. C. (57). **E**

*Anderson William G., M. D., Director Yale University Gymnasium, New Haven, Conn. (52). 1906. **H K**

Anderson, Winslow, M. D., President of College of Physicians and Surgeons of San Francisco, 1025 Sutter St., San Francisco, Cal. (51). **K**

Andrews, Champe S., 37 Liberty St., New York, N. Y (57).

Andrews, Clement Walker, Librarian of The John Crerar Library, Chicago, Ill. (53). **C**

*Andrews, Frank Marion, Ph. D., Asst. Professor Botany, Indiana University, Bloomington, Ind. (52). 1903. **G**

Andrews, Wm. Edward, Principal Township High School, Taylorville, Ill. (52). **D**

Andrews, William Symes, care Gen'l Elec. Co., Schenectady, N. Y. (50). **D E**

Angier, Roswell Parker, Yale University, New Haven, Conn. (57). K

Angle, Dr. Edward H., 1023 North Grand Ave., St. Louis, Mo. (53). F

Anthony, Gardner Chace, Prof. of Technical Drawing and Dean of the Engineering Dept. of Tufts College, Tufts College, Mass. (56). D

*Anthony, Prof. Wm. A., Cooper Union, New York, N. Y. (28). 1880. B

Apple, Joseph H., President of the Woman's College, Frederick, Md. (52). I

*Appleton, John Howard, Sc. D., Professor of Chemistry, Brown University, Providence, R. I. (50) 1901. C

*Archibald, Raymond Clare, Sackville, New Brunswick, Canada. (54). 1906. A

*Argall, Philip, Mining and Metallurgical Engineer, 730 Majestic Building, Denver, Col. (54). 1906. C E

Armfield, Frank, Attorney-at-Law, Monroe, N. C. (55). I

Armitage, Thomas L., M. D., Princeton, Minnesota. (51). K

*Armsby, Henry Prentiss, Director Agrl. Expr. Station, State College, Centre Co., Pa. (52). 1903. C

ARMSTRONG, S. T., M. D., 144 East 37th St., New York, N. Y. (57). K

*Arnold, Bion Joseph, 4128 Prairie Ave., Chicago, Ill. (50). 1903. D

Arnold, Ernst Hermann, M. D., Director New Haven Normal School of Gymnastics, 46 York Square, New Haven, Conn. (52). K

Arnold, Harold De Forrest, 13 Observatory Hall, Middletown, Conn. (57). B

Arnold, James Loring, Asst. Prof. Physics, New York University, 418 West 118th St., New York City. (57). B

*Arnold, Ralph, U. S. Geological Survey, Washington, D. C. (51). 1906.. E

*Arthur, J. C., D Sc., Botanist Agric. Exper. Sta., Purdue Univ., Lafayette, Ind. (21). 1883. G

Ascham, Louis, 420 W. Willow St., Chippewa Falls, Wis. (54). F G

Asdale, William James, M. D., Professor of Gynecology, Western Penna. Medical College, Pittsburg, Pa. (51). K

Ashbrook, Donald Sinclair, 905 Del. Ave., Wilmington, Del. (51). C

*Ashley, George Hall, U. S. Geol. Survey, Washington, D. C. (51). 1903. E F

Ashley, Jessie, 5 Nassau St., New York, N. Y. (57).

*Ashton, Charles Hamilton, Assistant Professor of Mathematics, University of Kansas, Lawrence, Kansas. (53). 1906. A

Aspinwall, John, Newburgh, N. Y. (49).

Astor, Col. John Jacob, 23 West 26th St., New York, N. Y. (57). I

Atkins, Martin D., 269 Forest Ave., River Forest, Ill. (48). B

Atkinson, Dr. D. A , 602 Oakwood Ave., West View, Pa. (56).

*Atkinson, George F., Cornell University, Ithaca, N. Y. (39). 1892. G

Atkinson, John B., Earlington, Ky. (26). D

*Atwell, Charles B., Northwestern Univ., Evanston, Ill. (36). 1890. G

Auchincloss, Hugh, M. D., 24 East 48th St., New York, N. Y. (57). K

*Auchincloss, Wm. S., 314 South Olive St., Los Angeles, Cal. (29). 1886. A D

*Austen, Prof. Peter T., 204 West 86th St., New York, N. Y. (44). 1896. C

Austin, C. F., Horticulturist, Estacion Central Agronomica, Santiago de las Vegas, Cuba. (54). G

Austin, F. E., Hanover, N. H. (57). D

*Austin, Oscar P., Chief of Bureau of Statistics, Dept. of Commerce and Labor, Washington, D. C. (51). 1907. I

*Avery, Elroy M., Ph. D., LL. D., 2831 Woodhill Road, S. E., Cleveland, Ohio. (37). 1899. B

Avery, Samuel, Director Chemical Laboratories, University of Nebraska, Station A, Lincoln, Neb. (57). C

Ayer, Edward Everett, 1515 Railway Exchange Bldg., Chicago, Ill. (37). H

Aymar, J., 70 West 54th St., New York, N. Y. (57).

Ayres, Horace B., Aitkin, Minn. (40).

Babasinian, Vahan S., St. Luke's Place, So. Bethlehem, Pa. (57). C

Babbitt, James A., M. D., 121 S. 18th St., Philadelphia, Pa. K

Babcock, Charles A., Supt. Schools, Oil City, Pa. (52). F

Babcock, Ernest Brown, Instructor in Agriculture, Los Angeles Normal School, 1443 Burlington Ave., Los Angeles, Cal. (57). G

*Babcock, Prof. S. Moulton, 432 Lake St., Madison, Wis. (33). 1885. C

Babcock, W. Wayne, M. D., 3302 No. Broad St., Philadelphia, Pa. (54). K

*Baber, Zonia, Associate Prof. Geography, School of Education, University of Chicago, Chicago, Ill. (54). 1906. E

Bacon, Arthur Avery, Professor of Physics, Hobart College, Geneva, N. Y. (53). B

Baehr, George, 78 West 94th St., New York, N. Y. (57). K

Baekeland, L. H., Harmony Park, Yonkers-on-Hudson, N. Y. (57). C

Baerecke, John F., M. D., Professor of Biology, Stetson University, DeLand, Fla. (50). F K

Bagby, J. H. C., Dept. Physical Science, Hampden-Sidney College, Hampden-Sidney, Va. (50). B

*Bagg, Rufus Mather, Jr., Ph. D., 1048 Riverdale St., West Springfield, Mass. (49). 1903. E

BAGGALEY, RALPH, Pittsburg, Pa. (50). D

*Bailey, E. H. S., Professor of Chemistry, Univ. of Kansas, Lawrence, Kan. (25). 1889. C E

Bailey, E. P., 32 Silver Road, Brockton, Mass. (52). E

Bailey, Frank H., Com'dr, U. S. N., 15 Halsey St., Brooklyn, N. Y. (52). D

*Bailey, Solon Irving, Associate Prof. Astronomy, Harvard Observatory, Cambridge, Mass. (50). 1901. A

*Bailey, Vernon, Department of Agriculture, Washington, D. C. (52). 1904. F

*Bain, Samuel M., Professor of Botany, University of Tennessee, Knoxville, Tenn. (50). 1902. G

*Bair, Joseph Hershey, Ph. D., Professor of Psychology, University of Colorado, Boulder, Colo. (52). 1905. H K

*Baird, John Wallace, University of Illinois, Urbana, Ill. (53). 1905. H

*Baird, Lucy H., 341 South 18th St., Philadelphia, Pa. (54). 1906. I

*Baird, Robert Logan, Principal, Denmark Academy, Denmark, Iowa. (53). 1907. F

Baker, A. G., Springfield, Mass. (44).

*Baker, Carl F., Botanist, Estacion Central Agronomica, Santiago de las Vegas, Cuba. (54). 1906. G

Baker, E. F., 511 West 122d St., New York, N. Y. (57).

*Baker, Frank, M. D., 1728 Columbia Road, Washington, D. C. (31). 1886. F H K

Baker, Frank C., Curator and Asst. Secy., Chicago Academy of Science, Chicago, Ill. (58).

Baker, Frederic, 815 Fifth Ave., New York, N. Y (40).

Baker, Hugh P., Asst. Professor Dept. Hort. and Forestry, Iowa State College, Ames, Iowa. (51). G

*Baker, James H., LL.D., President of the University of Colorado, Boulder, Colo. (50). 1903. I

Baker, Lucy A., Professor Music, Wisconsin State Normal School, Whitewater, Wisconsin. (57). G

*Baker, Robt. H., Allegheny Observatory, Allegheny, Pa. (54). 1907. **A**

Baker, Smith, M. D., Winston Building, Utica, N Y. (54). **K**

*Bakewell, Charles Montague, Yale University, New Haven, Conn. (54). 1906. **I**

Balch, Dr. Alfred William, Assistant Surgeon, U. S. N., U. S Naval Medical School, Washington, D C. (52). **C K**

*Balch, Edwin Swift, 1412 Spruce St., Philadelphia, Pa (51). 1903. **E H**

Balch, Francis Noyes, Hunneman & Balch, 60 State St., Boston, Mass. (50). **F**

Baldwin, A. E., M. D., 34–36 Washington St., Chicago, Ill. (54). **K**

Baldwin, Mrs. Gertrude H., 3 Madison Ave., Detroit, Mich. (34). **H**

Baldwin, Helen, 53 East 20th St., New York, N. Y. (54). **C**

Baldwin, Herbert B., Analytic and Consulting Chemist, 927 Broad St., Newark, N. J. (43).

*Baldwin, Prof. J. Mark, Johns Hopkins Univ., Baltimore, Md. (46). 1898. **H**

*Baldwin, Hon. Simeon E., Associate Judge of Supreme Court of Errors, New Haven, Conn. (50). 1901. **I**

*Baldwin, S. Prentiss, 736 Prospect St., Cleveland, Ohio. (47). 1900. **E**

Ball, Albert, Cooper Union, New York, N. Y. (58). **B**

*Ball, Carleton R., U. S. Dept. Agriculture, Washington, D. C. (49). 1902. **G**

*Ball, Elmer Darwin, Professor of Zoölogy and Entomology, State Agricultural College, Logan, Utah. (50). 1903. **F**

Ball, Miss Helen Augusta, 43 Laurel St., Worcester, Mass (50). **F**

Ballard, C. A., Curator of Museum, State Normal School, Moorhead, Minn. (51).

*Balliet, Thomas M., New York Univ., Washington Square, New York, N. Y. (48). 1903. **H I**

Ballou, Henry A., Entomologist, Imperial Dept. Agriculture, Barbados, B. W. I. (56). **F**

*Bancroft, Frank Watts, Ph. D., Instructor in Physiology, University of California, Berkeley, Cal. (50). 1907. **F K**

Bancroft, J. Sellers, M. E., 919 Pine St., Philadelphia, Pa. (51). **D**

Bancroft, Jesse H., Dept. Education, City of New York, 500 Park Ave., New York, N. Y. (58).

*Bancroft, Wilder Dwight, Professor of Chemistry, Cornell University, Ithaca, N. Y. (50). 1901. **B C**

BANGS, LEMUEL BOLTON, M. D., 39 E. 72d St., New York, N. Y. (36).

*Bangs, Outram, 20 Pemberton Square, Boston, Mass. (47). 1900. F

*Banker, Howard J., Prof. Biology, Depauw Univ., Greencastle, Ind. (51). 1905. G

Banks, Chas. S., Entomologist, Bureau of Science, Manila, P. I. (57). F

Banta, Arthur M., 125 Mt. Auburn St., Cambridge, Mass. (53). F

Barber, René Raoul, B. Sc., F. R. G. S., Georgetown, Ontario, Canada. (56). C

Barbour, Miss Carrie Adeline, Dept. of Geology, Univ. of Nebraska, Lincoln, Neb. (53). E

*Barbour, Erwin Hinckley, Prof. of Geology, Univ. of Nebraska Lincoln, Neb. (45). 1898. E

*Barbour, Thomas, Mus. Comp. Zoölogy, Harvard Univ., Cambridge, Mass. (50). 1907. F

Barck, Dr. Carl, 2715 Locust St., St. Louis, Mo. (52).

*Bardeen, Charles Russell, Professor of Anatomy, University of Wisconsin, Madison, Wis. (50). 1901. F K

Bardeen, Charles William, 406 So. Franklin St., Syracuse, N. Y. (52).

Barhydt, Mrs. P. Hackley, 40 E. 70th St., New York, N. Y. (57).

Barkan, Adolph, M. D., LL.D., James Flood Building, San Francisco, Cal. (51). K

Barker, Lewellys, F., M. D., Professor of Medicine, Johns Hopkins Univ., 63 E. Franklin St., Baltimore, Md. (57). K

*BARKER, PROF. G. F., 3909 Locust St., Philadelphia, Pa. (13). 1875. B C

Barker, Mrs. Martha M., 42 Eleventh St., Lowell, Mass. (31). H

Barker, Vincent K., 207½ E. Kennedy St., Syracuse, N. Y. (54). F G

Barlow, John, Professor of Zoölogy, R. I. College of A. and M. Arts, Kingston, R. I. (51). F

*Barnard, Edward E., Yerkes Observatory, Williams Bay, Wis. (26). 1883. A

Barnes, Cecil, 402 Dearborn Ave., Chicago, Ill. (57). E

*Barnes, Charles Reid, Ph. D., Univ. of Chicago, Chicago, Ill. (33). 1885. G

BARNES, MISS CORA F., 6 E. 65th St., New York City. (57).

Barnes, Edward W., Box 446, New York, N. Y. (49).

Barnes, Fred Asa, Asst. Prof. of Civil Engineering, Cornell University, Ithaca, N. Y. (56). D

Barnes, Howard Turner, Associate Prof. of Physics, McGill University, Montreal. (57). B

Barnes, Miss Mildred, 6 East 65th St., New York, N. Y. (57).

Barnes, Dr. William, Decatur, Ill. (57). K

Barnett, Mrs. Lelia Jefferson, Physics Building, Tulane University, New Orleans, La. (52). A

Barnett, Robert Crary, C. E., 510 Kansas City Life Bldg., Kansas City, Mo. (51). D

Barnhart, Arthur M., 185 Monroe St., Chicago, Ill. (42).

*Barnhart, John H., M. D., Tarrytown, N. Y. (49). 1903. G

Barnsley, George Thomas, Consulting Engineer, Fitzsimons Bldg., Pittsburgh, Pa. (51). D

*Barnum, Miss Charlotte C., Ph. D., U. S. Coast and Geodetic Survey, Washington, D. C. (36). 1896. A

Barnum, William M., 62 Cedar St., New York, N. Y. (57).

Barr, Charles Elisha, Professor of Biology, Albion College, Albion, Mich. (50). F

*Barr, John Henry, care of Smith Premier Typewriter Co., Syracuse, N. Y. (51). 1903. D

*Barrell, Joseph, Yale University Museum, New Haven, Conn (51). 1905. E

Barrie, Dr. George, The Highlands, Washington, D. C. (49). HI

Barringer, Daniel Moreau, Geologist and Mining Engineer, 460 Bullitt Building, Philadelphia, Pa. (50). DE

Barron, George D., Box 198, Rye, N. Y. (57)

Barrows, Chas. L., Mechanical Engineer, 56 Park Place, Newark, N. J. (57). D

*Barrows, Walter B., Professor of Zoölogy and Geology, Agricultural College, Mich. (40). 1897. F

Barrows, William Morton, Prof. of Zoölogy and Geology, Manchester College, North Manchester, Ind. (57). $F_1$

Barry, D. E., 447 Lexington Ave., New York, N. Y. (57)

Bartholomew, C. E., Instructor in Zoölogy, Iowa State College, Ames, Iowa. (54). F

*Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. C

*Bartlett, Francis, 40 State St., Boston, Mass. (50). 1906. I

Bartlett, George Miller, Instructor in Drawing and Descriptive Geometry, University of Michigan, Ann Arbor, Mich. (52). B

Bartlett, John P., 205 West 57th St., New York, N. Y. (57).

*Bartley, Elias H., M. D., 21 Lafayette Ave., Brooklyn, N. Y. (33). 1894. C

*Barton, G. E., 419 N. High St., Millville, N. J. (46). 1898. C

*Barton, George Hunt, Teacher's School of Science, 234 Berkeley St., Boston, Mass. (47). 1900. E

Barton, Philip Price, E. E., Sup't Niagara Falls Power Co., 127 Buffalo Ave., Niagara Falls, N. Y. (50). **DE**

*Barton, Samuel M., Ph. D., The Univ. of the South, Sewanee, Tenn. (43). 1899. **A**

Bartow, Chas. S., 67 William St., N. Y. City. (57).

*Bartow, Edward, Ph. D., University of Illinois, Urbana, Ill. (47). 1906. **C**

*Bartsch, Paul, Ph. D., Smithsonian Institution, Washington, D. C. (52). 1906. **F**

Baruch, Edgar, M. S., Hamilton, Cal. (56). **C**

*Barus, Carl, Ph. D., Wilson Hall, Brown Univ., Providence, R. I. (33). 1887. **B**

Barwell, John William, Waukegan, Ill. (47).

*Bascom, Miss Florence, Bryn Mawr College, Bryn Mawr, Pa. (42). 1897. **E**

Bashore, Dr. Harvey B., West Fairview, Pa. (46). **E**

*Baskerville, Charles, Professor of Chemistry, College of the City of New York, New York, N. Y. (41). 1894. **CE**

Baskett, James Newton, Mexico, Mo. (50). **FI**

*Basquin, Olin H., Associate Professor of Physics, Northwestern University, Evanston, Ill. (53). 1906. **B D**

Bassett, Carroll Phillips, Ph. D., Civil and Consulting Engineer, Summit, N. J. (51). **D**

Bassett, William H., Chief Chemist American Brass Co., 146 Litchfield St., Torrington, Conn. (57). **C**

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Bates, Henry H., Ph. D., 1201 M St., N.W Washington, D. C. (52). **A B D**

*Bates, Rev. John Mallery, Red Cloud, Neb. (51). 1903. **G I**

Baugh, Margaret L., 15 West 67th St., New York, N. Y. (57).

*Bauer, Louis A., Ph. D., The Ontario, Washington, D. C. (40). 1892. **A B**

Baumgardt, B. R., 626 W. 30th Street, Los Angeles, Cal. (51). **A**

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Bausch, Henry, P. O. Drawer 1033, Rochester, N. Y. (41).

*Bawden, H. Heath, Professor of Psychology and Philosophy, Vassar College, Poughkeepsie, N. Y. (51). 1905. **F**

*Baxter, Gregory Paul, First National Bank Bldg., Portland, Me. (54). 1906. **C**

Baxter, James Phinney, President, Maine Historical Society Portland, Maine. (50). **H I**

*Bayley, Wm. Shirley, Univ. of Illinois, Urbana, Ill. (53). 1905. **E**

Beach, Miss Alice M., Brookside, Calistoga, Cal. (50). F

Beach, Charles Coffing, M. D., 54 Woodland St., Hartford, Conn (50). F K

Beach, Miss Ella, Peekskill, N. Y. (57).

Beach, Henry Harris Aubrey, M. D., 28 Commonwealth Ave., Boston, Mass. (50). F K

*Beach, Spencer Ambrose, Iowa State College, Ames, Iowa. (41). 1900. G

Beal, James Hartley, Professor of Pharmacy, Scio College of Pharmacy, Scio, Ohio. (54). C

Beal, Walter Henry, Assistant, Office of Experiment Stations, U. S. Dept. Agriculture, Washington, D. C. (52).

*Beal, Wm. James, Ph. D., Professor of Botany, Agricultural College, Mich. (17). 1880. G

Beal, Wm. R., 1 West 12th St., New York, N. Y. (57).

Beaman, George Herbert, 2232 Mass. Ave. N.W., Washington, D. C. (52). I

*Beardsley, Arthur E., Professor of Biology, Colorado State Normal School, Greeley, Colo. (50). 1901. F

Beates, Henry, Jr., M. D., President of State Board of Medical Examiners, 1504 Walnut St., Philadelphia, Pa. (51). K

Beattie, Frederick Steve, Assistant in Chemistry, Brown Univ., 43 Illinois St., Central Falls, R. I. (57). C

Beattie, J. C., D. Sc., F. R. S. E., South African College, Cape Town, S. Africa. (54). F

Beatty, A. Chester, 71 Broadway, New York, N. Y. (57).

Beatty, James W. F., Pitcairn, Pa. (51).

Bebb, Edward C., U. S. Reclamation Service, Glendive, Montana. (52). E

*Beck, Carl, M. D., Professor of Surgery, New York Postgraduate Medical School, President of St. Mark's Hospital, 37 E. 31st St., New York, N. Y. (51). 1906. K

Beck, Herbert H., Assistant Professor of Chemistry, Franklin and Marshall College, Y. M. C. A. Building, Lancaster, Pa. (53). C

*Becker, Dr. Geo. F., 1700 R. I. Ave., Washington, D. C. (36). 1890. E

Beckwith, Miss Florence, Scottsville, N. Y. (45). G

Beckwith, T. D., Agric. College, N. D. (57). K

*Bedell, Frederick, Ph. D., Cornell Univ., Ithaca, N. Y. (41). 1894. A B

*Beebe, C. William, Curator of Ornithology, N. Y. Zoölogical Park, New York, N. Y. (53). 1905. F

*Beebe, Silas Palmer, Physiological Chemist to the Huntington Fund for Cancer Research, 216 Central Ave., Flushing, N. Y. (54). 1906. K

*Beede, Joshua William, Indiana University, Bloomington, Ind. (50). 1906. E

Beekman, Gerard, 7 East 42d St., New York, N. Y. (49).

Beer, Edwin, M. D., 116 West 58th St., New York, N. Y. (56). K

Beer, William, Chief Clerk, New Orleans Public Library, New Orleans, La. (54). H

Beers, Everett Jacob, 50 La Fayette Ave., Geneva, N. Y. (57). B C

Beeson, Jasper Luther, Professor Natural Science, Georgia Normal and Industrial College, Milledgeville, Ga. (57). C

Behr, Edward, C. E., 838 Carroll St., Brooklyn, N. Y. (57). D

*Behrend, Bernhard Arthur, C. E., E. E., Station H, Cincinnati, Ohio. (50). 1903. D E

Belknap, Henry Wyckoff, 40 Chestnut St., Salem, Mass. (57).

Bell, J. Finley, M. D., Englewood, New Jersey. (57). K

*Bell, Alex. Graham, Ph. D., 1331 Conn. Ave., N.W., Washington, D. C. (26). 1879. B H I

*Bell, Albert T., Professor of Botany, Wesleyan Univ., University Place, Neb. (52). 1903. G

Bell, C. M., M. D., 320 Fifth Ave., New York, N. Y. (36).

*Bell, John Everett, M. E., care of The Stirling Consolidated Boiler Co., 111 Broadway, New York, N. Y. (53). 1906. D

*Bell, Robert, M. D., LL.D., F. R. S., Geol. Survey, Ottawa, Can. (38). 1889. E F

Bell, William B., Asst. Prof. Zoölogy and Physiology, Agricultural College, N. D. (56). F

Beller, William Frank, B. S., Chief Liquidating Clerk, New York Custom House, 51 East 123d St., New York, N. Y. (56). F H I

Bellows, Horace M., M. D., Huntingdon Valley, Pa. (51). K

*Belmont, August, 23 Nassau St., New York, N. Y. (50). 1906. I

Belmont, Hon. Perry, 580 Fifth Ave , New York. (57).

*Beman, Wooster W., Univ. of Michigan, Ann Arbor, Mich. (34). 1886. A

Bement, A., Consulting Mining and Mech Engineer, American Trust Bldg., Chicago, Ill. (52). B C E

Béndrat, Rev. Thomas Albert, Constableville, N. Y. (52). E G

Benedict, Francis Gano, Professor of Chemistry, Wesleyan Univ., Middletown, Conn. (55). C

Benedict, Harris Miller, Instructor in Biology, University of Cincinnati, 103 West St. Clair St., Cincinnati, Ohio. (52). F

Benedict, Wm. de L., Mining Engineer, 43 Cedar St., New York, N. Y. (57).

*Benjamin, Marcus, U. S. National Museum, Washington, D C (27). 1887. C I

*Benneson, Miss Cora Agnes, A. M., LL. B., 4 Mason St., Cambridge, Mass. (47). 1899. I

*Bennett, A. A., Professor of Chemistry, Iowa State College, Ames, Iowa. (54). 1906. C

Bennett, Charles W., Coldwater, Mich. (50). E

Bennett, Edward, Electrical Engineer, 1502 H St. N.W., Washington, D. C. (52). D

Bennett, Henry C., Hotel Longacre, 157 West 47th St., New York, N. Y. (43).

Bennett, Homer Clark, The National College of Electro-Therapeutics, 210 W. Market St., Lima, O. (54). K

Bennett, John N., Doane College, Crete, Neb. (57).

*Bennett, William Z., Ph.D., Director of Chemical Laboratory, Univ. of Wooster, Wooster, Ohio. (48) 1903. C

Bentley, Gordon M., University of Tennessee, Knoxville, Tenn. (54) F

*Bentley, I. Madison, Assistant Professor of Psychology, Cornell University, Ithaca, N. Y. (54). 1906. K

*Bentley, William B., Professor of Chemistry, Ohio University, Athens, Ohio. (51). 1903. C

Bentley, Wilson A., Jericho, Vt. (48).

Benton, Frank, 925 N. St. N. W., Washington, D. C. (54). F

*Benton, John Robert, Ph. D., Dept. of Physics and Electrical Engineering, Univ. of Florida, Gainesville, Fla. (51). 1906. B

Berg, William N., Assistant in Physiological Chemistry, Columbia Univ., New York, N. Y. (55). C

Bergen, J. Y., 47 Raymond St., No. Cambridge, Mass. (57).

Bergen, Van Brunt, Shore Road and 77th St., Brooklyn, N. Y. (54). I

Berger, E. W., Ph. D., Entomologist Fla. Exp. Sta., Gainesville, Fla. (57). F

*Bergey, David H., S. E. cor. 34th and Locust Sts., Philadelphia, Pa. (48). 1903. K

*Bergström, John Andrew, Ph. D., Professor of Education, Indiana University, Bloomington, Ind. (50). 1901. I

Berkeley, Wm. N., Ph. D., Food Lab., Appraisers Stores, Philadelphia, Pa. (49). C

*Berkey, Charles Peter, Ph. D., Tutor in Geology, Columbia University, New York, N. Y. (50). 1905. E

Bernays, Augustus Charles, M. D., 3623 Laclede Ave., St. Louis, Mo. (50). FK

Bernheimer, Charles L., P. O. Box 1158, New York, N. Y. (49).

Berolzheimer, Daniel D., care of Helington Chemical Co., Yonkers, N. Y. (55). C

Berry, Daniel, M. D., Carmi, Ill. (41). BCE

Berry, Edgar H., care of Edw. A. Miller, 21 East 101st St., New York, N. Y. (56). D

*Berry, Edward W., Johns Hopkins Univ., Baltimore, Md. (50). 1905. G

Berry, John Wilson, C. E., Pittston, Pa. (47).

*Bessey, Charles Edwin, Ph. D., LL. D., Univ. of Nebraska, Lincoln, Neb. (21). 1880. G

*Bessey, Ernst A., Subtropical Laboratory, Miami, Fla. (49). 1901 G

Bessey, J. Mortimer, M. D., 1814 Adams St., Toledo, Ohio. (51). K

Best, George Newton, M. D., Rosemont, N. J. (54). K

*Bethune, Rev. C. J. S., Ontario Agricultural College, Guelph, Ontario, Canada. (18). 1875. F

Betten, Cornelius, Lake Forest, Ill. (56). F

Betts, Sam'l R., 120 Broadway, New York, N. Y. (57).

Betts, William Royston, M. D., 1331 Eighth St., New Orleans, La. (55). K

Beutenmüller, Wm., Dept. Entomology, Am. Mus. Nat. History, New York, N. Y. (57). F

Bevier, George, Jr., 702 Alice Ave., Spokane, Washington (55). D

Bevier, Miss Isabel, Univ. of Illinois, Urbana, Ill. (46) C

*Beyer, Geo. Eugene, Prof. of Biology, Tulane University, New Orleans, La. (54). 1906. F G

*Beyer, Prof. Samuel W., Iowa Agricultural College, Ames, Iowa. (47). 1900. E

*Bibbins, Arthur Barneveld, Curator and Instructor in Geology and Mineralogy, The Woman's College of Baltimore, The Somerset, 2600 Maryland Ave., Baltimore, Md. (54). 1906. E

*Bickmore, Prof. Albert S., Amer. Mus. Nat. History, Central Park, New York, N. Y. (17). 1880. H

Bicknell, George H., the University of Nebraska College of Medicine, Omaha, Neb. (55). K

Biddle, James G., 1024 Stephen Girard Building, Philadelphia, Pa. (33).

*Bien, Julius, 140 Sixth Ave., New York, N. Y. (34). 1905. E H

Bierbaum, Christopher H., M. E., Consulting Engineer, 434 Prudential Building, Buffalo, N. Y. (53). D

Bierly, H. Elmer, Editor Southern Educational Review, Grant Univ., Chattanooga, Tenn. (49). H

Bierwirth, Julius C., M. D., 137 Montague St., Brooklyn, N. Y. (51). K

*Bigelow, Prof Frank H., U. S. Weather Bureau, Chicago, Ill. (36). 1888. A B

Bigelow, Harriet W , Acting Director, Smith College Observatory Northampton, Mass (57) **A**

Bigelow, Henry Bryant, Mus. Comp. Zöology, Cambridge, Mass. (52).

Bigelow, John, 21 Grammercy Park, New York, N. Y. (57).

*Bigelow, Maurice Alpheus, Ph. D., Adjunct Professor of Biology, Teachers' College, Columbia Univ., New York, N. Y. (51). 1903. **F**

Bigelow, Robert Payne, Ph.D., Mass. Institute of Technology, Boston, Mass. (51). 1903. **F**

*Bigelow, S. Lawrence, Ph.D., Asst. Professor of General Chemistry, University of Michigan, Ann Arbor, Mich. (51). 1903. **C**

*Bigelow, W. D., Bureau of Chemistry, Department of Agriculture, Washington, D. C. (53). 1906. **G**

Bigelow, Dr. Wm. Sturgis, 56 Beacon St., Boston, Mass. (57). **K**

Bigney, Andrew J., Professor of Biology and Geology, Moores Hill College, Moores Hill, Ind. (50). **E F**

Bijur, Moses, 136 Water St., New York, N. Y. (57).

Billings, Miss E., 279 Madison Ave., New York, N. Y. (50). **I**

Billings, Frank, 35 East 22d St., Chicago, Ill. (58). **K**

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Biolley, Pablo, Prof., San Jose, Costa Rica, C. A. (56) **F**

Bird, Henry, Rye, N. Y. (55). **F**

Bird, Robt. Montgomery, Ph. D., Professor Chemistry, Univ. of Missouri, Columbia, Missouri. (57). **C**

Birdsall, Mrs. W. R., 41 Congress St., Bradford, Pa. (57).

*Birge, Edward A., Dean of College of Letters and Science, University of Wisconsin, Madison, Wis. (53). 1905. **F**

Bishop, Howard Beckey, B. S., Chemist, General Chemical Co., 609 Greene Ave., Brooklyn, N. Y (56). **C**

Bishop, James Hall, 2520 Gough St., San Francisco, Cal. (51). **H**

Bishop, Mrs. Josephine Hall, 2309 Washington St., San Francisco, Cal. (51). **H**

*Bishop, L. B., M. D., 356 Orange St., New Haven, Conn. (50). 1906. **I**

Bishop, Rev. Sam'l H., 500 West 122d St., New York City. (57).

Bishopp, Fred C., U S. Dept. Agriculture, Washington, D. C. (54) **F**

*Bissell, G. W., Michigan Agriculture College, East Lansing, Mich. (53). 1905. **D**

Bissell, Leslie Dayton, Ph.D., St. Paul's School, Concord, N. H. (50). **B**

Bissing, William F., 49 Wall St., New York, N Y. (55). **B**

Bitner, Henry F., Ph. D., Teacher of Natural Science, First Pennsylvania State Normal School, Millersville, Pa. (52). **B C G**

*Bitting, Katherine Golden, Lafayette, Ind. (42). 1897. G
*Bixby, Col. W. H., Corps of Engineers, U. S. A., U. S. Engineer's Office, Room 506, Federal Bldg., Chicago, Ill. (34). 1892. D
*Black, Homer V., Georgia School of Technology, Atlanta, Ga. (52). 1906. C
Black, N. Henry, 15 Ellery St., Cambridge, Mass. (50) B
Blackall, Clarence Howard, Architect, 1 Somerset St., Boston, Mass. (50). D
Blackburn, Isaac Wright, M. D., Pathologist, Government Hospital for the Insane, Washington, D. C. (55). K
Blackmore, Henry S., 206 S. 9th Ave., Mount Vernon, N. Y. (49).
*Blackshear, Edward Levoisier, Principal of the Prairie View State Normal and Industrial College, Prairie View, Texas. (52). 1907. HI
Blackwelder, Eliot, University of Wisconsin, Madison, Wis. (55). E
*Blain, Alexander W., Jr., M. D., Harper Hospital, Detroit, Mich. 1906. (52).
*Blair, Andrew Alexander, 406 Locust St., Philadelphia, Pa. (44). 1896. C
Blair, Mrs. Eliza N., 1410 20th St. N. W., Washington, D. C. (40).
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*Blake, Dr. Edwin Mortimer, 1910 Addison St., Berkeley, Cal. (43). 1901. A
*Blake, Francis, Auburndale, Mass. (23). 1874. AB
*Blake, William Phipps, Mill Rock, New Haven, Conn. (54). 1906. E
Blakeman, Mrs. Birdseye, 9 E. 44th St., New York, N. Y. (49).
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Blakeslee, Albert Francis, Botanical Museum, Harvard Univ., Cambridge, Mass. (52).
Blakiston, Kenneth M., 1012 Walnut St., Philadelphia, Pa. (54).
*Blanchard, Arthur Horace, C. E., Associate Professor of Engineering, Brown University, Providence, R. I. (52). 1905. BD
Bland, John Carlisle, Engineer of Bridges, Penna. Lines West of Pittsburg, 1003 Penn Ave., Pittsburg, Pa. (51). D
Blankinship, Joseph William, Ph. D., 4274A Florida Ave., St. Louis, Mo. (51). G
Blasdale, Walter Charles, Ph. D., Instructor in Chemistry, University of California, Berkeley, Cal. (50). C
Blauvelt, Harrington, Mining Engineer, Prescott, Ariz. (51). DE
*Bleile, Albert M., M. D., State University, Columbus, Ohio. (37). 1896. F

BLISH, W. G., Niles, Mich. (33). **B D**

*Bliss, Charles B., Ph. D., Hampden, Mass. (49). 1906. **H I**

Bliss, Hon. Cornelius N., P. O. Box 1499, New York, N. Y. (49)

*BLISS, GILBERT AMES, Princeton Univ., Princeton, N. J. (55). 1907. **A**

BLISS, MRS. WM. H., 6 East 65th St., New York City. (57).

*Blodgett, Frederick H., Johns Hopkins Univ., Baltimore, Md. (52). 1905. **G**

Bloodgood, John H., 155 W. 58th St., New York, N. Y. (49).

Bloodgood, Joseph Colt, Asst. Prof. Surgery, Johns Hopkins Univ. Baltimore, Md. (55). **F**

BLOUNT, HENRY FITCH, "The Oaks," Washington, D.C. (32). **B I**

Blum, Sanford, M. D., 1243 Franklin St., San Francisco, Cal. (52). **K**

Blum, William, Univ. of Utah, Salt Lake City, Utah. (55). **C**

Blumenthal, George, 23 West 53d St., New York, N. Y. (57).

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Blunt, Col. Stanhope English, Ordnance Dept., U. S. A., Commanding Springfield Armory, Springfield, Mass. (55). **D**

Boas, Emil L., 37 Broadway, New York, N. Y. (50). **I**

*Boas, Dr. Franz, 123 West 82d St , New York, N. Y. (36). 1888 **H I**

*Bodine, Donaldson, Professor of Geology and Zoölogy, Wabash College, Crawfordsville, Ind. (45). 1899. **E F**

Boerner, Wunibald R., Ravinia, Ill. (54). **D**

Bogert, Edw. Langdon, New Brighton, N. Y. (57).

*Bogert, Marston Taylor, Havemeyer Hall, Columbia Univ., New York, N. Y. (47). 1900 **C**

Boggs, Lucinda Pearl, Ph.D., Western College, Oxford, O. (57).

Bogue, Edward A., 63 West 48th St., New York, N. Y. (57).

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Bole, Ben P., Cleveland, Ohio. (57). **I**

Bolles, Newton Alden, 1457–59 Ogden St., Denver, Colo. (50). **C**

*Bolley, Henry L., Professor of Botany and Zoölogy, Agricultural College, North Dakota. (39). 1892. **F G**

*Bolton, Thaddeus, L., Ph. D., Dept. Philosophy, University of Nebraska, Lincoln, Neb. (50). 1901. **H I**

*Bond, Geo. M., 141 Washington St., Hartford, Conn. (33). 1885. **D**

Bond, R. I., M. D., Hartshorne, Ind. Ter. (50). **K**

Bondurant, Eugene Du Bose, M. D., Prof. Pathology and Bacteriology, University of Alabama, Mobile, Ala. (54). **K**

*Bonnet, Frederic, Jr., 16 Harvard St., Worcester, Mass. (53). 1906. **C**

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Boon, John Daniel, Professor of Physics, Chemistry and Geology, Polytechnic College, Ft. Worth, Texas. (50). BCE

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*Bouton, Charles Leonard, Instructor in Mathematics, Harvard University, Cambridge, Mass. (50). 1901. A

*Boutwell, John Mason, U. S. Geol. Survey, Washington, D. C. (46). 1905. E

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*Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. BFH

Bower, William Clinton, M. D., Lebanon, Kansas. (55). K

*Bowie, William, U. S. Coast and Geodetic Survey, Washington, D. C. (57). 1907. A D E

Bowker, R. R., 298 Broadway, New York, N. Y. (43). B

Bowlus, E. Lingan, Professor of Biology, Monmouth College, Monmouth, Ill. (50). F

Bowman, Charles Henry, Professor of Mechanics and Electrical Engineering, State School of Mines, Butte, Mont. (51). D

*Bownocker, J. A., Professor of Inorganic Geology, Ohio State University, Columbus, Ohio. (48). 1905. E

*Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

*Boyd, James E., Ohio State Univ., Columbus, Ohio. (46). 1899. B D

*Boyé, Martin H., M. D., Coopersburg, Pa. (1). 1896. C

Brace, Edith M., High School, Bloomfield, N. J. (54). FG

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Brackenridge, George W., San Antonio, Texas. (41). I

Brackett, Byron B., Ph. D., Clarkson School of Technology, Potsdam, N. Y. (46). B

*Brackett, Prof. C. F., Princeton University, Princeton, N. J. (19). 1875. B

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Brackett, Richard N., Clemson College, S. C. (37). 1891. C E

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BRADLEY, MILTON, Springfield, Mass. (44). B

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*Bradley, Walter Parke, Ph. D., Professor of Chemistry, Wesleyan University, Middletown, Conn. (50). 1906. C

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Brassill, Miss Sarah Ellen, South Weymouth, Mass. (47). F G

Braunnagel, Jules L. A., M. D., P. O. Box 925, San Antonio, Texas. (50). F

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Brayton, Sarah H., M. D., The Hereford, Evanston, Ill. (33).

Breed, Robert Stanley, Ph. D., Department of Biology and Geology, Allegheny College, Meadville, Pa. (51). F

Breese, Burtis Burr, Prof. of Psychology, Univ. of Cincinnati, Cincinnati, Ohio. (54). K

Breidenbaugh, Prof. Edward S., Pennsylvania College, Gettysburg, Pa. (57).

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*Brewer, Prof. Wm. H., P. O. Box 174, New Haven, Conn. (20). 1875. E F I
Brewster, Edwin Tenney, Instructor in Natural Sciences, Phillips Academy, Andover, Mass. (51).
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Briggs, Edward Cornelius, Harvard Medical School, Boston, Mass. (50). F K
*Briggs, Lyman J., U. S. Dept. Agriculture, Washington, D. C. (48). 1901. B
Briggs, Wallace Alvin, M. D., 1300 I St., Sacramento, Cal. (51). K
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Brigham, William T., Director of B. P. Bishop Museum of Polynesian Ethnology and Natural History, Honolulu, T. H. (54). H
Bright, Richard Riggs, Ordnance Bureau, Navy Dept., Washington, D. C. (52). D
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Brill, Nathan Edwin, M. D., 48 West 76th St., New York, N. Y. (54). H K
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Brittin, Lewis H., Ansonia, Conn. (52). H
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Britton, Wiley, Special Pension Examiner, Springfield, Mo. (40). F
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Broadhurst, Jean, Dept. Biology, Teachers' College, New York, N. Y. (54). G
Brock, Henry M., S. J., Professor of Physics, Holy Cross College, Worcester, Mass. (57). B
Brock, Luther S., M. D.. Morgantown, W. Va. (51). K

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Brooks, Charles, Durham, N. H. (53). G

Brooks, Charles Edward, Lake Roland, Md. (52). A

Brooks, J. Ansel, Instructor in Mech. Drawing, Brown University, Providence, R. I. (54). D

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Brooks, Prof. Wm. P., Amherst, Mass. (38). C F

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Brown, Glenn V., Plainfield, N. J. (51). B C E

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Budington, Robert A., Dept. Zoology, Wesleyan Univ., Middletown, Conn. (52). F K

Bües, Christian Rudolf August, care of Juan E. Talladares, Apartado 987, Lima, Peru. (56). F

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Bullene, Mrs. Emma F. Jay, 1409 Broadway, Denver, Colo. (50). H

Bullitt, James B., M. D., Professor of Anatomy, Univ. of Mississippi, University P. O., Miss (55). K

*Bumpus, H. C., Am. Mus. Nat. Hist., New York, N. Y. (49). 1900.

Burbank, John E., Cheltenham, Md. (57). B

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*Burgess, Edward S., 11 W. 88th St., New York, N. Y. (47). 1901 G

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Burk, W. E., Chief Chemist and Bacteriologist, Louisville Water Co., 1112 Hepburn Ave., Louisville, Ky. (55). C K

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Burnham, George, Jr., C. E., Burnham, Williams & Co., Baldwin Locomotive Works, 214 N. 34th St. Philadelphia, Pa. (51) D

Burns, Elmer Ellsworth, High School, Berwyn, Ill. (58). B C

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Burrell, Rámon Haddock, M. D., Creighton, Neb. (51). K

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*Burt, Edward Angus, Ph. D., Professor of Natural History, Middlebury College, Middlebury, Vt. (50). 1901. G

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Burton, E. F., Demonstrator in Physics, University of Toronto, Toronto, Ontario, Canada. (53). B

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*Burton-Opitz, Russell, Instructor in Physiology, Columbia University, New York, N. Y. (52). 1905. K

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Bush, John C. F., M. D., Wahoo, Neb. (51). K

*Bushnell, D. I., Jr., Assistant in Archæology, Peabody Museum, Cambridge, Mass. (52) 1903. H

Bustamanty, Delfin S., Sequi 1016, Adroqué, F. C. S., Argentine Republic, S. A. (57). G

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Butler, Bert S., Instructor in Physical Geography, Cornell University, 804 E. Seneca St., Ithaca, N. Y. (57). E

Butler, Matthew Joseph, Deputy Minister and Chief Engineer, Dept. Railways and Canals, Ottawa, Canada. (51). D

Butler, Paul, care of U. S. Cartridge Co., Lowell, Mass. (57). C

Butler, Wm. Mill, 321 St Nicholas Ave., New York City. (57).

Butterfield, Arthur Dexter, Professor of Mathematics and Mechanics, University of Vermont, Burlington, Vt. (50). A D

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Butts, Edward Pontany, C. E, Chief Engineer, Am. Writing Paper Co, Holyoke, Mass. (51). D

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Byrnes, Owen, Mining Engineer, Gould, Mont. (51). D E

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Cady, William Hamlin, Chemist, Continental Color Co., 127 Power St., Providence, R. I. (57). C

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Caldwell, Benjamin Palmer, Ph. D., Assistant Professor of Chemistry, Tulane Univ., New Orleans, La. (55). C

*Caldwell, Prof. Otis W., State Normal School, Charleston, Ill. (49). 1902. G

Calhoun, Fred H. H., Ph. D., Professor of Geology and Mineralogy, Clemson College, S. C. (54). E

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*Cameron, Frank K., Ph. D., Chemist, Bureau of Soils, U. S. Dept. Agriculture, Washington, D. C. (49). 1901. C

Cameron, John E., Central High School, Kansas City, Mo. (54). G

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Campbell, Leslie Lyle, Ph. D., Harvard University, Cambridge, Mass. (48).

*Campbell, Marius Robison, U. S. Geological Survey, Washington, D. C. (52). 1905. E

Campbell, Michael, M. D., Supt. Lyons View Insane Asylum, Knoxville, Tenn. (54). K

Campbell, Nathaniel A., 126 East 74th St., N. Y. (57).

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Canda, Chas. J., Nuthurst Summit, N. J. (57).

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*Cannon, Walter Bradford, Harvard Medical School, Cambridge, Mass. (54). 1906. K

Canter, Hall, Ph. D., Professor of Chemistry, Randolph-Macon College, Ashland, Va. (54). C

Carey, Everett P., San Jose High School, San Jose, Cal. (50). B C

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Carhart, Paul Worthington, Springfield, Mass. (56). B

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Carmichael, Robert Daniel, Prof. Mathematics, Alabama Presbyterian College, Anniston, Ala. (57). A

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Carpenter, Rev. Charles Knapp, Aurora, Ill. (55). F

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Case, Willard E., Auburn, N. Y. (57).

*Casey, Thomas L., Lt. Col. Corps of Engineers, U. S. A., Office of Light House Board, Washington, D. C. (38). 1892. D F

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CROWELL, A. F., Woods Holl, Mass. (30). C

*Crowell, John Franklin, care of The Wall Street Journal, New York, N. Y. (50). 1901. I

Crowley, Chas. F., John A. Creighton Medical College, Omaha, Neb. (53). C

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Cummins, George Wyckoff, M. D., Belvidere, N. J. (50). G K

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*Cunningham, Susan J., 3308 Arch St., Philadelphia, Pa. (38). 1901. A

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*Curtis, Winterton C., Ph. D., Asst. Prof. of Zoölogy, University of Missouri, Columbia, Mo. (53). 1905. F

Curtiss, C. F., Dean and Director, Iowa State College, Ames, Ia. (54). G

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*Cushing, Henry Platt, Adelbert College, Cleveland, Ohio. (33). 1888. E

*Cushman, Allerton, Ph. D., U. S. Dept. Agriculture, Washington. D. C. (50). 1901. C

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*Dawson, Percy Millard, M. D., Instructor in Physiology, Johns Hopkins University, Baltimore, Md. (50). 1903 K

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Donovan, Cornelius, Assistant Engineer, U. S. Engineer Office, Custom House, New Orleans, La. (51). D

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Dunipace, Joseph Evans, 107 E. Green St., Champaign, Ill. (57). C

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*Henchman, Miss Annie Parker, 8 Frisbie Place, Cambridge, Mass. (54). 1906. F
Henderson, Joseph J., 689 10th St., Brooklyn. N. Y. (51).
*Henderson, Junius, Curator of the Museum, Univ. of Colorado, Boulder, Colo. (50). 1906. F
Henderson, Royal L., 215 Church St., Richmond Hill, N. Y. (57).
*Henderson, William Edward, Ph. D., Associate Prof. Chemistry, Ohio State University, Columbus, Ohio. (50). 1901. C
Henderson, Yandell, 400 Prospect St., New Haven, Conn. (57). K
Hendrick, Ellwood, 139 East 40th St., New York City. (57).
Henel, Frank, M. D., 117 West 79th St , New York City. (57). K
Henius, Max, Ph. D., 327 Fullerton Ave., Chicago, Ill. (52). K
*Henmon, V. A. C., Univ. of Colorado, Boulder, Colo. (54). 1906. K
Hennen, Ray Vernon, C. E., L. B. 448, Morgantown, W. Va. (50). D
Henning, Gus. C., 521 N. 142d St., New York City. (57).
Henrich, Carl, Mining Engineer, Metasville, Ga. (50). A E I
*Henry, Alfred J., Professor of Meteorology, U. S. Weather Bureau, Washington, D. C. (49). 1901. B
Henry, Charles C., M. D., 56 Clark St., Brooklyn, N. Y. (43).
Henry, Stewart L., 908 S. Carrollton Ave., Station B., New Orleans, La. (55).
Hensel, Samuel Theodore, P. O. Box 14, Capital Hill Station, Denver, Colo. (50). C G
Henshaw, Henry W., Biological Survey, Dept. of Agriculture, Washington, D. C. (55). F H
Henszey, Sam'l Alexander, 51 Lincoln Place, Irvington, N. J. (51).
Herbert, Arthur P., Engineer and Supt. Colima Division, Compania Constructora Nacional Mexicana, Colima, Colima, Mex- (51). D

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*Hering, Rudolph, 170 Broadway, New York, N. Y. (33). 1885. **D E I**

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Herr, Hiero B., Monadnock Block, Chicago, Ill. (50) **E**

*Herrick, C. Judson, Hull Lab. of Anatomy, Univ. of Chicago, Chicago, Ill. (49). 1901. **F**

*Herrick, Francis Hobart, Professor Biology, Adelbert College, Cleveland, Ohio. (52). 1905. **F**

Herrick, Glenn W., Professor of Biology, A. and M. College, Agricultural College, Miss. (50). **F**

Herrick, Rev. Jos. C., St. Joseph Seminary, Yonkers, N. Y. (56)

HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

*Herrmann, Richard, Sec'y Iowa Institute of Science and Arts, Dubuque, Iowa. (50). 1902. **C E**

Herron, William Harrison, U. S. Geological Survey, Washington, D. C. (52). **D E I**

*Herter, Christian A., M. D., 819 Madison Ave., New York, N. Y. (50). 1902. **K**

*Herty, Charles Holmes, Ph. D., University of North Carolina, Chapel Hill, N. C. (42). 1895. **C**

*Hervey, Rev. A. B., Bath, Me. (22). 1879. **F**

Herzog, Felix Benedict, Ph. D., President Herzog Teleseme Co., 51 West 24th St., New York, N. Y. (50). **D**

Hertzog, P. H., Assistant to State Zoologist, Harrisburg, Pa. (57). **F**

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Hessler, Robert, M. D., Logansport, Ind. (54). **F K**

Heston, John W., President South Dakota Agricultural College, Brookings, S. D. (50). **I**

Hewett, Edgar L., 1333 F St., N. W., Washington, D. C. (50). **H**

Hewitt, Thomas Edwin, Chemist, U. S. Arsenic Mines Co., 331 Atwood St., Pittsburg, Pa. (56). **C**

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Heyer, Wm. D., Box 94, Elizabeth, N. J. (33). **B D**

Heyl, Paul Renno, Instructor in Physics, Central High School, Philadelphia, Pa. (54). **B**

Hibbard, Rufus P., Ph. D., U. S. Dept. Agriculture, Washington, D. C. (54).

*Hice, Richard R., Beaver, Pa. (51). 1906. **E**

Hichborn, C. S., Secretary State Survey Commission, Augusta, Me. (52). **I**

Higdon, John Clark, 605 Missouri Trust Bldg., St. Louis, Mo. (50). **B D I**

*Higdon, John E., 3939 Charles Ave., Indianapolis, Ind. (54). 1906. **A B D K**

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*Hill, Eben Charles, Johns Hopkins University, Baltimore, Md. (54). 1906. **K**

Hill, Edwin A., Assistant Examiner, U. S. Patent Office, Washington, D. C. (52). **D**

*Hill, George A., U. S. Naval Observatory, Washington, D. C. (47). 1900. **A**

*Hill, John Edward, Prof. of Civil Engineering, Brown University, Providence, R. I. (44). 1897. **D**

*Hill, Robert Thomas, Trinity Bldg., New York, N. Y. (36). 1889. **E**

Hill, Wm. K., Carthage College, Carthage, Ill. (54). **G**

*Hillebrand, William F., U. S. Geological Survey, Washington, D. C. (51). 1903. **C**

Hillig, Frederick J., S. J., St. Johns College, Toledo, Ohio. (50). **B**

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Hills, Alfred Kimball, M. D., 541 West End Ave., N. Y. (57). **K**

*Hillyer, Homer W., Ph. D., Chemical Laboratory, Univ. of Wisconsin, Madison, Wis. (42). 1896. **C**

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*Hilton, William A., 435 Penn. Ave., Waverly, N. Y. (49). 1906. **F**

*Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**

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Hinds, J. I. D., Ph. D., University of Nashville, Nashville, Tenn. (55). **C**
*Hinds, W. E., U. S. Dept. of Agriculture, Washington, D. C. (54). 1906. **F**
Hindshaw, Henry Havelock, Assistant in Geology, State Museum, Albany, N. Y. (52). **E**
*Hine, James S., Ohio State Univ., Columbus, Ohio. (48). 1903. **F**
Hinman, Edgar Linderson, Assoc. Prof. of Philosophy, Univ. of Nebraska, Lincoln, Neb. (54). **F**
*Hinrichs, Dr. Gustavus, 4106 Shenandoah Ave., St. Louis, Mo. (17). 1874. **B C**
Hinsdale, Wilbert B., M. D., Univ. of Michigan, Ann Arbor, Mich. (54). **K**
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Hirshfeld, Clarence Floyd, Asst. Prof. Steam Engineering, Cornell University, Ithaca, N. Y. (54).
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*Hitchcock, Albert Spear, Div. Agrostology, U. S. Dept. Agriculture, Washington, D. C. (39). 1892. **G**
Hitchcock, Miss Caroline Judson, Teacher in High School, Meriden, Conn. (50). **B E**
*Hitchcock, Charles H., LL. D., Hanover, N. H. (11). 1874. **E**
*Hitchcock, Miss Fanny R. M., 4038 Walnut St., Philadelphia, Pa. (35). 1906. **F**
*Hitchcock, Frank H., First Assistant Postmaster-General, Washington, D. C. (49). 1901. **I**
Hitchcock, George Collier, 709 Wainwright Bldg., St. Louis, Mo. (53). **I**
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Hoad, W. C., Associate Professor Civil Engineering, Univ. of Kansas, Lawrence, Kans. (54). **D**
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Hoagland, Henry Williamson, M. D., 327 N. Nevada Ave., Colorado Springs, Colo. (51). **F K**
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Hobbs, Prof. Perry L., Western Reserve Medical College, Cleveland, Ohio. (41). **C**

*Hobbs, William Herbert, Ph. D., Univ. of Michigan, Ann Arbor, Mich. (41). 1893. **E**

Hobby, C. M., M. D., Iowa City, Iowa. (51). **K**

Hobson, Hon. Richmond Pearson, 2117 S St. N. W., Washington, D. C. (54).

Hodge, Frederick Humbert, Instructor in Mathematics, Clark University, Worcester, Mass. (50). **A**

*Hodge, Frederick Webb, Smithsonian Institution, Washington, D. C. (52). 1903.

Hodge, James M., Big Stone Gap, Va. (29). **D E**

Hodges, Robert Shattuck, Chemist Ala. Geological Survey, University, Ala. (54). **C E**

*Hodgkins, Prof. H. L., George Washington University, Washington, D. C. (40). 1896. **A B**

Hodgkins, William Candler, Coast and Geodetic Survey, Washington, D. C. (52). **D**

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Hoffman, Conrad, Experiment Station, Madison, Wis. (57). **K**

Hoffman, Frank Sargent, Professor of Philosophy, Union University, Schenectady, N. Y. (52). 1906. **H**

Hoffman, Geo. Edgar, "Longcliff," Logansport, Ind. (57). **K**

*Hoffmann, Dr. Friedrich, Charlottenburg, Kant St. 125, Berlin, Germany. (28). 1881. **C F**

*Hoffman, Samuel V., Morristown, N. J. (52). 1906. **A D**

Hogan, Edgar Poe, Professor of Chemistry and Biology, Howard College, East Lake, Ala. (54). **C F**

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Holbrook, Percy, Gen'l. Mgr. Weber Ry. Joint Mfg. Co., 2528 Broadway, New York, N. Y. (51). **D**

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Holden, Mrs. L. E., The Hollenden, Cleveland, Ohio. (35).

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*Holland, W. J., D. D., LL. D., Director Carnegie Institute, Pittsburg, Pa. (57). 1896. **F**

*Hollick, Arthur, N. Y. Botanical Garden, Bronx Park, New York, N. Y. (31). 1892. **E G**

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Hollister, Frank, M. D., 264 West 77th St., New York City. (57). **K**

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Hollister, N., U. S. Dept. Agriculture, Washington, D. C. (57). F

Holman, R. Morris, Assistant in Botany, Stanford University, Palo Alto, California. (55). G

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Holmes, Miss Mary S., 1331 N. Twelfth St., Philadelphia, Pa. (50). E

*Holmes, S. J., Ph. D., University of Wisconsin, Madison, Wis. (51). 1903. F

*Holmes, Wm. H., Bureau of American Ethnology, Washington, D. C. (30). 1883. H

Holstein, George Wolf, Hamby, Texas. (28). E H

Holt, Erastus Eugene, M. D., 723 Congress St., Portland, Me. (54). K

Holt, Henry, 29 W. 23d St., New York, N. Y. (29).

Holton, Henry D., M. D., Brattleboro, Vt. (44). I

Holton, Nina G., U. S. Dept. Agriculture, Washington, D. C. (57).

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Homburg, Frederick, Teacher of Chemistry, Woodward High School, Cincinnati, Ohio. (51). C

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Hood, William, 512 Van Ness Ave., San Francisco, Cal. (35). D

Hooker, Davenport, 374 White Hall, Yale University, New Haven, Conn. (52). F

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Hooker, Henrietta, E., Ph. D., Professor of Botany, Mt. Holyoke College, South Hadley, Mass. (45). G

Hooker, John D., 325 West Adams St., Los Angeles, Cal. (51). A

Hooker, William A., U. S. Dept. of Agriculture, Washington, D. C. (54). F

Hooper, Everett, M. D., Ph. D., Warren Chambers, Boston, Mass. (57). C K

Hooper, Prof. Franklin W., Curator Brooklyn Institute, Brooklyn, N. Y. (43).

Hoopes, H. E., Media, Pa. (52). H

Hoose, James H., Ph. D., Professor of Philosophy, Univ. of Southern California, Los Angeles, Cal. (52). I

Hoover, Herbert C., 39 Hyde Park Gate, London, S. W., England. (51). E

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Hopeman, H., M. D., Minden, Neb. (51). **K**

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Hopkins, Albert Lloyd, 2904 West Ave., Newport News, Va. (51).

Hopkins, Anderson Hoyt, Librarian Carnegie Library, Pittsburg, Pa. (52).

*Hopkins, Prof. Arthur John, Amherst College, Amherst, Mass. (44). 1900. **C**

Hopkins, Cyril G., Chief in Agronomy and Chemistry, Univ. of Illinois, Agriculture Exp. Station, 1001 So. Wright St., Champaign, Ill. (57). **C**

Hopkins, George B., 52 Broadway, New York, N. Y. (50).

*Hopkins, Grant S., Cornell University, Ithaca, N. Y. (41). 1900. **F**

*Hopkins, Nevil Monroe, Asst. Professor of Chemistry, George Washington University, Washington, D. C. (48). 1901. **C D**

Hopkins, Rupert Henry, College Ave., Westerleigh, West New Brighton, N. Y. (54). **C**

Hopkins, Samuel A., M. D., 235 Marlboro St., Boston, Mass. (54). **K**

*Hopkins, Thomas Cramer, Syracuse University, Syracuse, N. Y. (38). 1898. **E**

Hormell, Prof. William G., Ohio Wesleyan Univ., Delaware, Ohio. (48). **B**

Hornung, Christian, Professor of Mathematics and Astronomy, Heidelberg, University, Tiffin, Ohio. (50). **A D**

*Horsford, Miss Cornelia, 27 Cragie St., Cambridge, Mass. (46). 1897. **H**

Horton, Byron Barnes, Sheffield, Pa. (54). **F G**

*Hortvet, Julius, State Chemist, Old Capitol, St. Paul, Minn. (50). 1906. **C**

*Hoskins, Leander Miller, Professor of Applied Mathematics, Stanford University, Cal. (54). 1906. **A**

*Hoskins, William, La Grange, Ill. (34). 1903. **C**

Hosmer, Geo. Washington, M. D., 7 East 73d St., New York City. (57). **K**

Hosmer, Sidney, E. E., Boston Electric Light Co., 3 Head Place, Boston, Mass. (50). **D**

Hotchkiss, Elmer Aro, President Champaign County Board of School Examiners, Mechanicsburg, Ohio. (52). **B**

Hotchkiss, Henry D., 315 West 75th St., New York City. (57).

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Hottenroth, Fred'k W., 981 Prospect Ave., Bronx, New York, City. (57).

Hottes, Charles Frederick, Asst. Prof. of Botany, Univ. of Illinois, Urbana, Ill. (54). **G**

*Hough, Prof. G. W., Northwestern University, Evanston, Ill. (15). 1874. **A B D**

*Hough, Theodore, Ph. D., Simmons College, Boston, Mass. (51). 1903. **K**

*Hough, Walter, U. S. National Museum, Washington, D. C (38). 1890.

*Houghton, E. Mark, 130 Longfellow Ave., Detroit, Mich. (52). 1906. **K**

Houk, Mrs. Eliza P. T., Cherry Angle, Dayton, Ohio. (48).

*Houser, Gilbert L., Ph. D., Professor Animal Biology, University of Iowa, Iowa City, Iowa. (50). 1906. **F K**

*Hovey, Edmund O., Amer. Mus. Nat. History, Central Park, New York, N. Y. (36). 1895. **C E**

*Hovey, Rev. Horace Carter, 60 High St., Newburyport, Mass. (29). 1883. **E H**

Howard, Arthur Day, Ph. D., Westminster College, New Wilmington, Pa. (57). **F**

Howard, Charles P., 116 Farmington Ave., Hartford, Conn. (51).

*Howard, Prof. Curtis C., 97 Jefferson Ave., Columbus, Ohio. (38). 1892.

Howard, Harry Turner, 3513 St. Charles Ave., New Orleans, La. (55).

Howard, Henry, 36 Amory St., Brookline, Mass. (57). **C**

Howard, Kenneth Samuel, Wards' Natural Science Establishment, 377 Grand Ave., Rochester, N. Y. (55). **C E**

*Howard, Leland O., Ph. D., Cosmos Club, Washington, D. C. (37). 1889. **F**

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Howard, Orson, M. D., Curator of Museum, University of Utah, Salt Lake City, Utah. (50). **F K**

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*Howard, William Travis, Jr., Prof. of Pathology, Western Reserve University, Cleveland, O. (54). 1906. K

*Howe, Charles S., President Case School of Applied Science, Cleveland, Ohio. (34). 1891. A

Howe, Clifton D., A. B., Ph D., Instructor in Botany, Biltmore Forrest School, Biltmore, N. C. (57). G

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*Howe, Herbert Alonzo, Director of the Chamberlin Observatory, University of Denver, University Park, Colo. (50). 1901. A

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Howe, J. Morgan, M. D., 12 West 46th St., New York, N. Y. (50).

*Howe, Marshall A., New York Botanical Garden, Bronx Park, New York, N. Y. (49). 1903. G

Howe, Reginald Heber, Jr., Middlesex School, Concord, Mass. (54). F G

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Howell, John W., Ballantine Parkway, Newark, N. J. (50).

*Howell, William H., M. D., Professor of Physiology, Johns Hopkins University, Baltimore, Md. (50). 1901. F K

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Howison, George Holmes, LL. D., Mills Professor of Philosophy, Univ. of California, Berkeley, Cal. (54). A

Howland, Howard Newell, 5451 Drexel Ave., Chicago, Ill. (50). F

Howland, Randolph H.. 164 Wildwood Ave., Upper Monclair, N. J. (54). F

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Hoyt, Adrian Hazen, M. D., Manager Whitney Electric Co., Penacook, N. H. (52). D

Hoyt, Olive Sawyer, Kobe College, Kobe, Japan. (52). C

*Hrdlicka, Alës, M. D., U. S. National Museum, Washington, D. C. (46). 1897. H

Hubbard, Geo. D., Asst. Prof. Geology, Ohio State Univ., Columbus, Ohio. (55). E

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Hudson, James A., Att'y and Counsellor-at-Law, Aldrich Court, New York City. (57).

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Hulbert, C. E., Secretary, Department of Anthropology, La. Purchase Exposition, St. Louis, Mo. (53). H

*Hull, Gordon Ferrie, Professor of Physics, Dartmouth College Hanover, N. H. (50). 1903. B

Hume, Alfred, C. E., University, Miss. (39). A

Hummel, John A., Experiment Station, St. Anthony Park, Minn. (48).

Humphrey, Henry Baker, Palo Alto, Cal. (55). G

*Humphrey, Richard L., Testing Laboratory, City Hall, Philadelphia, Pa. (48). 1892. D

Humphreys, Alex. C., M. E., C. E., 31 Nassau St., New York, N. Y. 1907. (49).

Humphreys, David Carlisle, C. E., Professor of Civil Engineering, Washington and Lee University, Lexington, Va. (53). D

Humphreys, Fred'k B., M. D., 78 West 85th St., New York City. (57). K

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Hunt, Arthur E., Teacher of Biology Manual Training High School, Brooklyn, N. Y. (54). F

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*Hunter, Andrew Frederick, Barrie, Ontario, Can. (38). 1896. B H I

Hunter, George William, 2238 Andrews Ave., University Heights, New York, N. Y. (52). **F**

*Hunter, Prof. J. Rufus, Raleigh, N. C. (45). 1899. **C**

*Hunter, Samuel John, Associate Professor of Entomology, University of Kansas, Lawrence, Kansas. (50). 1902. **F**

*Hunter, Walter David, U. S. Department Agriculture, Washington, D. C. (50). 1905. **F**

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Huntoon, Louis Doremus, Asst. Prof. Mining and Metallurgy, Sheffield Scientific School, Yale Univ., New Haven, Conn. (55). **D**

Hurd, E. O., Plainville, Ohio. (30). **E F**

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*Hyde, Prof. E. W., Station D, Cincinnati, Ohio. (25). 1881. **A**

Hyde, Frederick E., M. D., 11 W. 52d St., New York, N. Y. (43). **E**

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Hyde, Henry St. J., 210 E. 18th St., New York, N. Y. (49).

Hyde, Jesse E., Lancaster, Ohio. (57). **E**

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Iorns, Martin J., Mayaguez, Porto Rico. (50). **C G**

*Irving, John Duer, South Bethlehem, Pa. (51). 1903. **E**

*Isham, George Snow, M. D., 488 N. State St., Chicago, Ill. (54). 1906. **A K**

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Jaches, Leopold, M. D., Cornell University Medical College, 414 E. 26th St., New York City. (57). **K**

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*Jackson, Abraham Wendell, care of L. S. Jackson, 9 Desbrosses St., New York, N. Y. (54). 1906. **E**

*Jackson, Prof. Charles L., Harvard University, Cambridge, Mass. (44). 1895. **C**

Jackson, Holmes Condict, Ph. D., 997 Madison Ave., Albany, N. Y. (57). **K**

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Jacobs, Michael William, 222 Market St., Harrisburg, Pa. (50). **I**

*Jacobus, David S., Stevens Institute, Hoboken, N. J. (36). 1889. **A B D**

*Jacoby, Harold, Columbia University, New York, N. Y. (38). 1891. **A**

*Jacoby, Henry S., Professor of Bridge Engineering, Cornell University, Ithaca, N. Y. (36). 1892. D

Jaffa, Myer Edward, Berkeley, Cal. (47).

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Jarman, Joseph L., President and Prof. of Chemistry, State Female Normal School, Farmville, Va. (51). C

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Jayne, Harry W., 931 N. Broad St., Philadelphia, Pa. (54). C

*Jayne, Horace, 318 S. 19th St., Philadelphia, Pa. (29). 1884. F H

Jeans, Prof. J. H., F. R. S., Princeton, N. J. (57).

Jefferson, J. P., Manufacturer, Warren, Pa. (51). D I

*Jefferson, Mark S. W., Professor of Geology, State Normal College, Ypsilanti, Mich. (52). 1906. E

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Jeffrey, Robert Henry, Apartado 104, Oaxaca, Mexico. (53). G

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Jelly, George Frederick, M. D., 69 Newbury St., Boston, Mass. (50). F K

*Jenkins, Edw. H., Agricultural Station, New Haven, Conn. (33). 1885. C

Jenkins, Lawrence W., Curator of Ethnology, Peabody Museum, Salem, Mass. (57). H

*Jenkins, Oliver Peebles, Professor of Physiology, Stanford University, Cal. (52). 1905. F K

*Jenks, Albert E., 512 13th Ave. S. E., Minneapolis, Minn. (50). 1902. H

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Jenks, Wm. H., Brookville, Pa. (38).

Jenks, William Johnson, Electrical Engineer, 120 Broadway New York, N. Y. (50). B D

*Jenney, Walter Proctor, E. M., Ph. D., Consulting Geologist and Mining Engineer, Knutsford Hotel, Salt Lake City, Utah. (50). 1903. E

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Jennings, Fred Huntington, 9 Pleasant St., Watertown, N. Y. (57). C
Jennings, Gainor, M. D., West Milton, Ohio. (51). K
Jennings, H. S., Associate Prof. of Zoölogy, Johns Hopkins University, Baltimore, Md. (54). 1906. F
Jennings, Otto Emery, Carnegie Museum, Pittsburg, Pa. (53). G
*Jennings, Walter L., Worcester Polytechnic Institute, Worcester, Mass. (45). 1898.
Jensen, Chas. A., U. S. Department of Agriculture, Washington, D. C. (54) C
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*Jewell, Lewis E., Johns Hopkins University, Baltimore, Md. (49). 1906. A
*Jewett, Prof. Frank Fanning, Oberlin College, Oberlin, Ohio. (47). 1899. C
Jewett, Geo. Franklin, M. D., Britton, S. Dak. (51). K
Jewett, William Cornell, C. E., 541 Ridgeway Ave., Avondale, Cincinnati, Ohio. (52). D
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*Johannsen, Oskar Augustus, Asst. Prof. Civil Engineering, Cornell Univ., Ithaca, N. Y. (54). D
Johns, Carl, Professor of Natural History, Bethany College, Lindsborg, Kans. (50). F
Johnson, Alba B., Rosemont, Pa. (54).
Johnson, Albert Lincoln, C. E., 606 Century Bldg., St. Louis, Mo. (51). D
Johnson, Chas. Willison, Boston Society of Natural History, Boston, Mass. (51).
Johnson, Douglas Wilson, Instructor in Geology, Mass Inst. of Technology, Boston, Mass. (54). E
*Johnson, Duncan S., Ph. D., Associate Professor of Botany, Johns Hopkins University, Baltimore, Md. (54). 1906. G
Johnson, Frank Seward, M. D., 2521 Prairie Ave., Chicago, Ill. (51). K
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Johnson, John W., Prof. of Physics, Univ. of Mississippi, University, Miss. (55). B

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Johnson, Thomas Carskadon, Horticulture and Botany, College of Agriculture, West Virginia University, Morgantown, W. Va. (51) G

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Johnson, Col. Thomas Alexander, Supt. Kemper Military School. Boonville, Mo. (55).

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*Jones, Lewis Ralph, Professor of Botany, University of Vermont, Burlington, Vt. (41). 1894. G

*Jones, Lynds, M. Sc., Instructor in Zoology, Oberlin College, Oberlin, Ohio. (50). 1905. F

*Jones, Prof. Marcus E., Salt Lake City, Utah. (40). 1893. G

Jones, Richard Watson, LL. D., Laurel, Miss. (55). C
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Jordan, H. E., Ph. D., Adj. Prof. Histology and Embryology, Univ. of Virginia, Charlottesville, Va. (57). F
*Jordan, Whitman H., Director N. Y. Agric. Exper. Station, Geneva, N. Y. (45). 1902. I
Juat, Francis, M. D., Lakewood, Fla. (50). F K
*Judd, Dr. Charles H., Yale University, New Haven, Conn. (49). 1901. H I
Judd, Horace, Asst. Professor of Experimental Engineering, Ohio State University, 245 W. 4th Ave., Columbus, Ohio. (56). D
Judson, Champion Hiram, M. D., Dobbs Ferry, West Co., N. Y. (57). K
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Jungblut, Herman C., M. D., Tripoli, Iowa. (52). K
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Kaadt, Peter S., M. D., Clinton, Ia. (54). K
Kahl, Hugo, Carnegie Museum, Pittsburg, Pa. (50). F
*Kahlenberg, Louis, Ph. D., Professor of Physical Chemistry, Univ. of Wisconsin, Madison, Wis. (46). 1898. C
Kahn, Julius, 100 West 80th St., New York, N. Y. (50). C
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Kane, Thos. Franklin, Ph. D., President University of Washington, Seattle, Wash. (55). I
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Kay, Geo. Fred'k, B. S., A. M., Univ. of Kansas, Lawrence, Kans. (57). **E**

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Kearfott, W. D., Montclair, N. J. (54). **F**

*Kearney, Thomas H., U. S. Dept. Agriculture, Washington, D. C. (47). 1902. **G**

*Keasbey, Lindley Miller, Professor of Economics and Politics, Bryn Mawr College, Bryn Mawr, Pa. (51). 1903. **H I**

*Keep, Wm. J., 753 Jefferson Ave., Detroit, Mich. (37). 1897.

Keilholtz, Pierre Otis, Consulting Engineer, Continental Trust Building, Baltimore, Md. (50). **D**

Keim, Edward Tudor, E. E., Supt. Am. Dist. Tel. Co., 1421 Champa St., Denver, Colo. (50). **D E F**

Keith, John Meiggs, Manager Costa Rica Div. United Fruit Co., San José, Costa Rica, C. A. (54). **G**

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Keller, Emil E., Vice-President, The Westinghouse Machine Co., East Pittsburg, Pa.

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Kelley, Walter S., Mining Engineer, 1393 Golden Gate Ave., San Francisco, Cal. (50). **D**

Kellicott, Wm. E., Prof. of Biology, The Woman's College, Baltimore, Md. (57). **F**

Kellogg, John H., M. D., Battle Creek, Mich. (24). **F**

*Kellogg, Vernon Lyman, Professor of Entomology, Stanford University, California. (50). 1901. **F**

Kelley, Edward O. G., Urbana, Ill. (55). **F**

Kelly, John F., Ph. D., Consulting Electrical Engineer, 284 W. Housatonic St., Pittsfield, Mass. (50). **D**

Kelly, William, Mining Engineer, General Manager Penn. Iron Mining Co., Vulcan, Mich. (50). **D E**

Kelsey, James A., Dunlop, Iowa. (49).

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*Kemp, James F., School of Mines, Columbia University, New York, N. Y. (36). 1888. **F**

Kempton, Charles Walter, Mining Engineer, 29 Broadway, New York, N. Y. (54). E

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Kendall, Hugh F., Mining Engineer, Carlson Exploration Co., Hibbing, Minn. (50). E

*Kendall, William Converse, Bureau of Fisheries, U. S. Department of Commerce and Labor, Washington, D. C. (52). 1906. F

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Kennedy, Frank Lowell, Instructor in Lawrence Scientific School, Harvard University, Cambridge, Mass. (50).

Kennedy, George Golding, M. D., Readville, Mass. (40). F G

KENNEDY, HARRIS, 284 Warren St., Roxbury, Mass. (40). E F

Kennedy, Mary E., Mt. Holyoke College, South Hadley, Mass. (54). G

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Kent, James Martin, Instructor in Steam and Electricity, Manual Training High School, Kansas City, Mo. (50). D E

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Kenyon, Oscar Curtis, Teacher of Physics, High School, Syracuse, N. Y. (50). B

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*Kershner, Prof. Jefferson E., Franklin and Marshall College, Lancaster, Pa. (29). 1883. A B

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*Kester, Fred. Edward, Ohio State University, Columbus, Ohio. (48). 1906. B

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Kimball, Edwin Boyce, 519 East Lindsay St., Stockton, Cal. (50). D

Kimball, James H., Observer U. S. Weather Bureau, Milwaukee, Wis. (51). A B

Kimball, Horatio G., Chatham, N. J. (57).

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King, W. F., Chief Astronomer, Dept. Interior, Ottawa, Canada. (55). A

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*Kingsbury, Benj. F., Stimson Hall, Cornell University, Ithaca, N. Y. (45). 1899. F

Kingsbury, Joseph T., Pres. and Prof. of Chemistry, University of Utah, Salt Lake City, Utah. (57). C

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Knab, Frederick, U. S. National Museum, Washington, D. C. (53). F

Knapp, Alfred A., M. D., Brimfield, Ill. (51). K

Knapp, G. N., College of Agriculture, Madison, Wis. (46). G H

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Knapp, S. A., Ph. D., U. S. Dept. Agriculture, Washington, D. C. (54). G

Knauff, Francis Henry, Oak Lane, Philadelphia, Pa. (51). D

Knerr, Ellsworth B., Sc. D., Midland College, Atchison, Kan. (51).

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Knox, Francis H., Boise, Idaho. (50). D

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Knox, Rev. George Wm., Prof. of Philosophy, Union Theological Seminary, New York, N. Y. (55). H I

Knox, Henry H., Mining Engineer, 82 Beaver St., New York, N. Y. (50). D

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Krause, Otto H., Prospect Ave., Hackensack, N. J. (50).

Krécsy, Prof. Béla, VI Bulyovsxky u. 26, Budapest, Hungary. (41). C

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Kudlich, Herman C., 299 Broadway, New York City. (57).
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Kunze, Edward J., Dept. Mech. Engineering, Columbia Univ., New York. (57). **B D**
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Lachman, Samson, 313 West 106th St., New York City. (57).
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Ladd, George Tallman, care Bass Foundry and Machine Co., Fort Wayne, Ind. (51).
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Lampard, Henry, 51 Hallowell St., Westmont, Quebec. (40). **C D E**

Lanahan, Henry, Professor Physics and Civil Engineering, Maryland Agricultural College, College Park, Md. (52). **B D**

Lancaster, Walter B., M. D., Amherst, Mass. (51). **K**

Lance, Harold B., 167 Dana St., Wilkesbarre, Pa. (57). **G**

*Land, William Jesse Goad, Dept. Botany, Univ of Chicago, Chicago, Ill. (52). 1903. **G**

*Landacre, Francis L., Associate Professor of Zoology and Entomology, Ohio State University, Columbus, Ohio. (53). 1906. **F**

*Landes, Henry, State Geologist, Seattle, Wash. (51). 1903. **E**

Landis, Edward Horace, Instructor in Physics and Chemistry, Central High School, Philadelphia, Pa. (52). **A B C**

*Landis, Prof. W. W., Dickinson College, Carlisle, Pa. (50). 1906. **A**

Landon, Francis G., Staatsburg-on-Hudson, N. Y. (50).

*Landreth, Olin H., Professor of Engineering, Union University, Schenectady, N. Y. (28). 1883. **D**

*LANE, ALFRED C., State Geologist, Lansing, Mich. (50). 1902. **E**

Lane, Frank R., Director Jacob Tome Inst., Port Deposit, Md. (57).

Lane, Henry H., Dept. of Zoology, State University of Oklahoma, P. O. Box 111, Norman, Okla. (55). **F G**

Lane, Horace Manley, M. D., Rua da Consolacão 184, S. Paulo, Brazil, South America. (46).

Lange, J. D., 116 W. 39th St., New York City, N. Y. (49).

Lange, Philip A., Supt. Westinghouse Elec. and Mfg. Co., Pittsburg, Pa. (50). **D**

Langeloth, I., 784 Fifth Ave., New York City. (57).

*Langenbeck, Karl, 1434 Q St., N.W., Washington, D. C. (39). 1896. **C**

*Langmann, Gustav, M. D., 121 W. 57th St., New York, N. Y. (36). 1907.

*Langsdorf, Alexander Suss, Assistant Professor of Electrical Engineering, Washington University, St. Louis, Mo. (50). 1903. **B D**

Langworthy, Charles Ford, Department of Agriculture, Washington, D. C. (56). **C K**

Lansing, John Ernest, Hobart College, Geneva, N. Y. (52). **B C E**

Lantz, Miss Willie A., Teacher of Science, Woman's College, Frederick, Md. (54). **F G**

*Lanza, Prof. Gaetano, Mass. Institute Technology, Boston, Mass. (29). 1882. **A B D**

Laramy, Robert Edward, 511 South Gay St., New York City. (51). **E**

Lare, H. S. P., M. D., 3452 Park Ave., St. Louis, Mo. (49).

*Larkin, Edgar L., Director of Lowe Observatory, Echo Mountain, Cal. (51). 1903. A

Larkin, John Charles, M. D., Hillsboro, Ohio. (54). K

Larocque, Jas., 40 Wall St., New York City. (57).

Larrabee, Austin P., Teacher of Biology, Salt Lake High School, Salt Lake City, Utah. (54). F

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Lathbury, B. Brentnall, C. E., Consulting Engineer, Land Title Bldg., Philadelphia, Pa. (51). D

Lathrop, Francis, 29 Washington Square, New York City. (57).

Latta, James Edward, Teacher of Physics, Univ. of North Carolina, Chapel Hill, N. C. (54). B

Latta, John Milton, M. D., 113 N. Lawrence St., Wichita, Kans. (54). K

*Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. C

Lauder, George, 7403 Penn Avenue, Pittsburg, Pa. (50).

Lauman, George Nieman, Instructor in Horticulture, Cornell University, Ithaca, N. Y. (50). G

Lavers, Enoch C., Ph. D., 126 Porter St., Easton, Pa. (54). A

Law, Benedict W., Collins, N. Y. (45). E

Lawbaugh, Elmer Arthur, Oregonian Building, Portland, Oregon, (52). K

*Lawrence, A. E., 53 Devonshire St., Boston, Mass. (49). 1906. B

Lawrence, Florus F., M. D., Chief of Staff and Surgeon, Lawrence Hospital for Women, 423 East Town St., Columbus, Ohio. (53). K

Lawrence, G. Alfred, 10 East 58th St., New York City. (57).

*Lawrence, Harry E., Univ. of Rochester, Rochester, N. Y. (44). 1906. B

Lawrence, James W., Professor of Mechanical Engineering, Agricultural College, Fort Collins, Colo. (50). D

*Laws, Frank Arthur, Mass. Institute Technology, Boston, Mass. (47). 1906.

Laws, Samuel Spahr, LL. D., 1733 Q St. N. W., Washington, D. C. (52). H

*Lawson, Andrew C., Professor of Geology and Mineralogy, University of California, Berkeley, Cal. (50). 1901. E

Lay, Henry Champlin, Civil and Mining Engineer and Geologist, U. S. Deputy Mineral Surveyor, Telluride, Colo. (51). D E

Lazell, Ellis W., Ph. D., care of H. S. Spackman Engineering Co., 42 N. 16th St., Philadelphia, Pa. (51). C

*Lazenby, W. R., Columbus, Ohio. (30). 1882. B I
*Lea, Henry C., 2000 Walnut St., Philadelphia, Pa. (54). 1906.
*Leach, Miss Mary F., Western College, Oxford, Ohio. (44). 1896. C
*Leaming, Edward, 437 West 59th St., New York, N. Y. (50). 1901. C
*Leavitt, Frank M., Mechanical Engineer, 258 Broadway, New York, N. Y. (51). 1903. D.
*Leavitt, Henrietta S., Harvard College Observatory, Cambridge, Mass. (55). 1907. A
*Le Baron, J. Francis, Civil and Mining Engineer, R. F. D. 3, Chardon, Ohio. (51). 1903. E
*Le Brun, Mrs. Michel M., 8 Mountain Ave., S., Montclair, N. J. (35). 1892. F
Le Conte, Louis Julian, Civil Engineer, P. O. Box 482, Oakland, Cal. (51). D
Le Conte, Robert Grier, M. D., 1530 Locust St., Philadelphia, Pa. (51). K
*Ledoux, Albert R., Ph. D., 99 John St., New York, N. Y. (26) 1881. C
Lee, Edwin, Professor of Physics and Chemistry, Mt. Union College, Alliance, Ohio. (53). B C F
*Lee, Frederick S., Adjunct Professor of Physiology, Columbia University, New York, N. Y. (49). 1901. K
*Lee, Leslie A., Professor of Biology, Bowdoin College, Brunswick, Me. (52). 1906. F
Lee, Tennant, 318 or 319 Godchaux Bldg., New Orleans, La. (55).
*Lee, Thomas G., Prof. Histology and Embryology, Univ. of Minnesota, Minneapolis, Minn. (55). 1907. K
Lee, Waldemar, 4620 Wayne St., Philadelphia, Pa. (50).
*Lee, Prof. Willis Thomas, U. S. Geological Survey, Washington, D. C. (47). 1902. E F
*Leeds, Morris E., 3221 North 17th St., Philadelphia, Pa. (50). 1906.
*Lefavour, Henry, President Simmons College, Boston, Mass. (42). 1894. B
Le Fevre, Egbert, M. D., 52 West 56th St., New York City. (57). K
Lefevre, George, Ph. D., Univ. of Missouri, Columbia, Mo. (55). F
*LeGras, Gustave, Asst. Prof. Mathematics, College of the City of N. Y., New York, N. Y. (54). 1906. A
LEHMAN, MEYER H., 667 Madison Ave., New York City. (57).
*Leidy, Joseph, Jr., M. D., 1319 Locust St., Philadelphia, Pa. (51). 1906. K

Leisen, Theo. Alfred, Civil Engineer, Wilmington, Del. (51) **B C D G**

*Leith, Charles Kenneth, Professor ot Economic and Structural Geology, University of Wisconsin, Madison, Wis. (53). 1906. **E**

Leland, Ora Miner, Asst. Prof. Astronomy and Geodesy, Cornell Univ., Ithaca, N. Y. (54). **A D**

Lemley, C., McC., Asst. Engineer, B. & O. R. R. Co., 1712 N. Calvert St., Baltimore, Md. (51). **D**

Lemon, James S., Ph. D., 31 Park St., Gardner, Mass. (51). **I K**

Leng, Charles W., 119 Columbia St., West New Brighton, Staten Island, N. Y. (54). **F**

*Lengfeld, Felix, Ph. D., Consulting and Manufacturing Chemist, 1804 Fillmore St., San Francisco, Cal. (51). 1903. **C**

*Lenher, Victor, Ph. D., Assistant Professor of Chemistry, Univ. of Wisconsin, Madison, Wis. (52). 1903. **C**

*Lennon, William H., State Normal School, Brockport, N. Y. (31). 1894. **C G**

Leonard, John William, Editor of "Who's Who in America," 22 Morningside Ave., New York City. (50). **I**

Lesher, Arthur L., 670 Broadway, New York City. (57).

Lesley, Robert W., 604 Pennsylvania Building, Philadelphia, Pa. (54).

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*Levene, Dr. P. A., 154 W. 132d St., New York, N. Y. (53). 1906. **K**

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Leverson, Montague Richard, M. D., 927 Grant Ave., Bronx, New York, N. Y. (54). **K**

*Levy, Ernest C., M. D., 615 East Franklin St., Richmond, Va. (54). 1906. **C K**

Lewis, A. B., C. E. Seward, Alaska. (55). **D**

Lewis, Dr. Bertha, Box 215, Malvern, Pa. (54).

Lewis, Clarence McKenzie, care Wm. Salomon & Co., 25 Broad St., New York, N. Y. (47). **D**

*Lewis, E. Percival, Associate Professor of Physics, University of California, Berkeley, Cal. (53). 1905. **B**

Lewis, George Smith, 746 State St., Springfield, Mass. (44). **G**

*Lewis, J. Volney, Rutgers College, New Brunswick, N. J. (45). 1900. **C E**

Lewis, Dr. Warren H., Associate Professor of Anatomy, Johns Hopkins University, Baltimore, Md. (57). **K**

Lewis, Daniel C., Milville, N. J. (57) **C D**

Lewis, Wilfred, Pres. The Tabor Mfg. Co., 5901 Drexel Road, Philadelphia, Pa. (51). 1906. D

Lewisohn, Adolph, 42 Broadway, New York City. (57).

Lewton, Frederick Lewis, U. S. Dept. Agriculture, Washington, D. C. (54). F G

Lewton-Brain, L., Asst. Director, Div. Path. or Physiol. Exper. Sta., H. S. P. A., Honolulu, T. H. (55). G

Libbey, Frederick A., 30 Broad St., New York City. (57).

*Libbey, Prof. William, Princeton, N. J. (29). 1887. EF

Lichtenauer, Jos. M., M. D., 20 Broad St., New York City. (57). K

Lichthardt, G., Jr., 1800 M St., Sacramento, Cal. (50). C

Lichty, Daniel, M. D., Masonic Temple, Rockford, Ill. (52). K

Lieb, J. W., Jr., 57 Duane St., New York City. (57).

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Light, Dr. Gertrude Underhill, Women's University Club, 17 Madison Sq. N., New York, N. Y. (53). K

Lightfoot, Thos. Montgomery, Asst. Prof. of Physical Science, Central High School, Philadelphia, Pa. (51). G

Lightner, Calvin R., M. D., 2313 Washington Ave., St. Louis, Mo. (53). K

Lihme, C. B., La Salle, Illinois. (57). C

*Lillie, Frank R., Professor of Zoology, University of Chicago, Chicago, Ill. (50). 1901. F

Lincoln, Francis Church, 467 West 163d St., New York City. (57).

Lindahl, John Harold Josua, Ph.D., Dir. Mus. Cin. Soc. Nat. Hist., P. O. Box 597, Cincinnati, Ohio. (55). F

Lindenkohl, Henry, U. S. C. and G. Survey, Washington, D. C. (47).

*Lindenthal, Gustav, C. E., 45 Cedar St., New York, N. Y. (37) 1891. I

*Lindgren, Waldemar, U. S. Geological Survey, Washington, D. C. (53). 1906. E

*Lindley, Ernest H., Professor Psychology, University of Indiana, Bloomington, Ind. (52). 1905. K

Lindsay, Alexander M., Rochester, N. Y. (41).

Lindsay, John D., 31 Nassau St., New York City. (57).

*Lindsay, Samuel McCune, Columbia University, New York City. (54). 1906. I

*Lindsey, Edward, Warren, Pa. (48). 1906. HI

Lines, Edwin Fuller, U. S. Geological Survey, Washington, D. C. (54). E

Linford, James Henry, President of the Brigham Young College, Logan, Utah. (52). F

*Ling, Charles Joseph, Instructor in Physics, Allegheny College, Meadville, Pa. (50). 1901. AB

*Ling, George Herbert, Ph. D., Tutor in Mathematics, Columbia University, New York, N. Y. (52). 1906. **A**

Link, Theodore Carl, Carleton Bldg., St. Louis, Mo. (51). **I**

*Linn, Alvin Frank, Ph. D., Professor of Chemistry, Wittenberg College, Springfield, Ohio. (50). 1901. **C**

Linn, George A., M. D., P. O. Box 813, Monongahela, Pa. (51). **K**

*Linton, Edwin, Biological Laboratory, Washington and Jefferson College, Washington, Pa. (51). 1905. **F**

*Linville, Henry R., 313 West 82d St., New York, N. Y. (40). 1906.

Lion, Léon Elie, C. E., Assistant on U. S. Engineer Corps, 1010 Burgundy St., New Orleans, La. (51). **D**

Lipp, Charles Clinton, Asst. Veterinarian Minn. Exper. Station, St. Paul Minn. (53). **K**

Lischer, Benno Edward, M. D., 504 Humboldt Bldg., St. Louis, Mo. (53). **K**

Litchfield, Lawrence, M. D., 5431 Fifth Ave., Pittsburg, Pa. (51). **K**

*Littell, Frank B., U. S. Naval Observatory, Washington, D. C. (49). 1903. **A**

*Little, Arthur D., Chemist, 93 Broad St., Boston, Mass. (54). 1906. **C**

Little, Henry P., Superintendent of Union Schools, Momence, Ill. (50). **B**

*Littlehales, G. W., 2132 Le Roy Place, Washington, D. C. (52). 1903. **A B D E**

*Livingston, Burton Edward, Ph. D., U. S. Dept. Agriculture, Washington, D. C. (53). 1906. **G**

Livingston, Luther S., Scarsdale, N. Y. (57).

Livingston, Max, 1158 So. Broad St., Philadelphia, Pa. (54). **D**

*Lloyd, Francis E., Intercontinental Rubber Co., Hacienda de Cedros Mayapil Zac, Mexico. (48). 1901. **G**

*Lloyd, John Uri, The Lloyd Library, 224 West Court St., Cincinnati, Ohio. (38). 1890. **C F**

Lloyd, Morton Githens, Ph. D., Bureau of Standards, Washington, D. C. (52). 1906. **B**

Lloyd, T. Mortimer, M. D., 125 Pierrepont St., Brooklyn, N. Y. (51). **K**

Lober, John B., 1230 Land Title Bldg., Philadelphia, Pa. (57)

*Lochhead, William, Professor of Biology, Macdonald College, Montreal, St. Anne de Bellevue, Quebec, Can. (51). 1906. **F**

Locke, Geo. Herbert, 29 Beacon St., Boston, Mass. (57). **L**

Lockwood, Cornelius Wygant, Teacher of Science, Newburg Academy, Newburgh, N. Y. (50). **B E**

Lockwood, Edwin Hoyt, Asst. Prof. Mechanical Engineering, Yale University, New Haven, Conn. (50). **D**

Lodholz, Edward, M. D., University of Pennsylvania, Philadelphia, Pa. (53). K

Loeb, James, 52 William St., New York City. (57).

*Loeb, Leo, M. D., University of Pennsylvania, Philadelphia, Pa. (51). 1905. K

*Loeb, Morris, Ph. D., 273 Madison Ave., New York, N. Y. (36). 1889. C

*Loew, Dr. Oscar, Komaba, Tokyo, Japan. (49). 1900. G

*Loewenstein, Louis C., Instructor in Mechanical Engineering, Lehigh Univ., So. Bethlehem, Pa. (54). 1905. D

Loewy, Benno, 206 and 208 Broadway, New York, N. Y. (41).

Logan, Frank G., 2919 Prairie Ave., Chicago, Ill. (42). H

Lomb, Adolph, P. O. Drawer 1033, Rochester, N. Y. (41).

Lomb, Henry, P. O. Drawer 1033, Rochester, N. Y. (41).

Lomb, Henry C., care of Bausch & Lomb Opt. Co., Rochester, N. Y. (43).

*Long, Prof. John H., 2421 Dearborn St., Chicago, Ill. (41). 1895. C

Long, William Henry, Jr., No. Texas State Normal School, Denton, Texas. (50).

Longaker, Daniel, M. D., 1402 N. 16th St., Philadelphia, Pa. (53). K

*Longden, A. C., Ph. D., Professor of Physics, Knox College, Galesburg, Ill. (49). 1901. B

*Longstreth, Morris, 1416 Spruce St., Philadelphia, Pa. (54). 1906.

*Loomis, Elmer Howard, Prof. Physics, Princeton Univ., Princeton, N. J. (54). 1906. B

Loomis, Frederick B., Ph. D., Assistant in Zoology, Amherst College, Amherst, Mass. (50). F

Lord, Franklin B., 49 Wall St., New York City. (57).

Lord, John Prentiss, M. D., 501 Paxton Blk., Omaha, Neb. (55). K

*Loubat, le Duc de, 47 rue Dumont d'Urville, Paris, France. (46). 1897. H

*Louderback, George Davis, University of California, Berkeley, Cal. (50). 1906. E

*Lough, Dr. J. E., New York University, Washington Square, New York, N. Y. (50). 1901. I

Loughlin, Gerald Francis, Instructor in Geology, Mass. Institute of Technology, Boston, Mass. (57). E

*Loughridge, Dr. R. H., Univ. of California, Berkeley, Cal. (21). 1874. CE

Lounsbury, Charles P., Government Entomologist, Dept. of Agriculture, Cape Town, South Africa. (52). F

*Love, Edward G., 80 E. 55th St., New York, N. Y. (24). 1882. C

*Love, James Lee, Asst. Prof. Mathematics, Harvard Univ., Cambridge, Mass. (54). 1906. A

Lovejoy, J. R., Genl. Elec. Co., Schenectady, N. Y. (50). D

LOVELAND, HORACE HALL, M. D., Newark, N. J. (51). K

*Lovett, Edgar Odell, Professor of Mathematics, Princeton University, Princeton, N. J. (51). 1902. A

Low, A. A., Columbia Heights, Brooklyn, N. Y. (43). A

Low, Clarence F., Liverpool, London, Globe Bldg., New Orleans, La. (52). I

*Low, Hon. Seth, 30 East 64th St., New York, N. Y. (29). 1890.

*Lowber, Rev. James William, Ph. D., 113 East 18th St., Austin, Texas. (50). 1906. H I

Lowe, E. N., M. D., Assistant in Biology, The University of Mississippi, University, P. O., Miss. (55). F K

Lowe, Houston, V. P., The Lowe Bros. Co., Dayton, Ohio. (52). G

Lowe, Morgan M., M. D., 621 Opelousas Ave., Algiers, La. (55). K

*Lowell, Percival, 53 State St., Boston, Mass. (36). 1896. A

Lowell, Russell C., 420 Hope St., Providence, R. I. (51).

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Lucas, Daniel Ralph, Livingston Hall, Amsterdam Ave. and 115th St., New York, N. Y. (57). K

Luckey, Geo. W. A., Professor of Education, University of Nebraska, 1439 R St., Lincoln, Neb. (156). F G

Luckey, John Eddy, M. D., Vinton, Ia. (51). I K

Ludlow, Miss Clara S., The Plaza, Washington Circle, Washington, D. C. (54).

*Ludlow, Henry Hunt, Lt-Col. U. S. A. Coast Artillery Corps, Fort Hamilton, N. Y. (54). 1906. A

*Ludlow, Jacob Lott, C. E., 434 Summit St., Winston, N. C. (50). B D

Luebkert, Otto, American Audit Co., Colorado Building, Washington, D. C. (50). I

Lukens, Herman T., South-Western State Normal School, California, Penna. (55). H I

Lull, Richard S., Amherst, Mass. (43). F H

Lum, Elizabeth S., Elizabeth, N. J. (57).

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Lund, James, 142 Hawthorne St., Malden, Mass. (45).

Lund, Robert Leathan, 5968 W. Cabanne Place, St. Louis, Mo. (53). D

*Lundin, Carl A. R., care Messrs. Alvan Clark and Sons, Cambridgeport, Mass. (47). 1906. **A**

*Luquer, Lea McIlvane, Columbia University, New York, N. Y. (49). 1902. **E**

*Lusk, Graham, 11 E. 74th St., New York, N. Y. (54). 1906. **F K**

Luther, Miss Agnes Vinton, 151 Scotland Road, South Orange, N. J. (47). **E**

Lutz, Anne M., Secretary Station for Exper. Evolution, Cold Spring Harbor, L. I., N. Y. (54). **F**

Lutz, Frank Eugene, Station for Experimental Evolution, Cold Spring Harbor, L. I., N. Y. (53). **F**

Lybrand, Mrs. William M., 5325 Wayne Ave., Germantown, Pa. (54). **I**

*Lyford, Edwin F., Springfield, Mass. (33). 1896. **B C H**

*Lyle, David A., Lieut. Colonel U. S. Army, Augusta Arsenal, Augusta, Ga. (28). 1880. **D**

*LYMAN, BENJ. SMITH, 708 Locust St., Philadelphia, Pa. (15). 1905. **E**

Lyman, Chester W., Assistant to President of International Paper Co., 30 Broad St., New York, N. Y. (50). **I**

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Lyman, George Richard, Asst. Prof. of Botany, Dartmouth College, Hanover, N. H. (57). **G**

Lyman, Henry H., F. R. G. S., F. E. S., 74 McTavish St., Montreal, Can. (29). **E F**

Lyman, James, Engineer, Western District, Genl. Elec. Co., 1047 Monadnock Bldg., Chicago, Ill. (50). **D**

*LYMAN, THEODORE, Instructor in Physics, Harvard Univ., Cambridge, Mass. (55). 1907. **B**

Lynch, William H., Prince Public Schools, Cabool, Mo. (52). **I**

Lyon, Marcus Ward, Jr., U. S. National Museum, Washington, D. C. (53).

Lyon, Scott Cary, Asst. Professor of Science, Southwestern Presbyterian University, Clarksville, Tenn. (55). **B C**

Lyon, T. Lyttleton, Cornell Univ., Ithaca, N. Y. (56). **C G**

Lyons, Albert Brown, M. D., Consulting Chemist, 72 Brainard St., Detroit, Mich. (50). **C K**

*Lyons, Robert E., Professor of Chemistry, University of Indiana, Bloomington, Ind. (51). 1906. **C**

*Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio. (29). 1881. **C**

McAdam, D. J., Professor of Engineering, Washington and Jefferson College, Washington, Pa. (51). **A**

*MacAlister, James, President Drexel Institute, Philadelphia, Pa. (54). 1906. I

*McAllister, Cloyd North, Ph. D., Warrensburg, Mo. (52). 1906. K

McAlvin, J. G., M. D., Box 153, Route 1, Pasadena, Cal. (52). K

McArthur, Lewis L., M. D., 4415 Drexel Blvd., Chicago, Ill. (51). K

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Macbeth, George A., 717 Amberson Ave., Pittsburg, Pa. (50). D H

McBeth, William A., Asst. Professor of Geography, State Normal College, Terre Haute, Ind. (53). E

McBride ,Hon. George Wickliffe, Portland, Oregon. (51). I

McBride, Jas. H., M. D., Pasadena, Cal. (51). K

McBurney, Chas., 38 East 31st St., New York City. (57).

Macbride, Thomas H., Iowa City, Iowa. (38). 1890. G

McCallie, James Park, Ph.D., H. P. Station, Chattanooga, Tenn. (57). A

McCartney, Dr. James H., 929 Lake Ave., Rochester, N. Y. (41). A B

*McCaskey, H. D., Chief, Division of Mines, Bureau of Science, Manila, P. I. (55). 1907. E

McCastline, William H., M. D., Instructor in Physical Education Teachers' College, Columbia University, New York, N. Y. (56). K

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McCay, Prof. Le Roy Wiley, Princeton, N. J. (57). C

McClelland, James H., M. D., 5th and Wilkins Aves., Pittsburg, Pa. (50). F K

McClendon, Jesse F., Prof. Biology, Randolph-Macon College, Ashland, Va. (57). F

*McClintock, Emory, 32 Nassau St., New York, N. Y. (43). 1895. A

McClung, Clarence E., Ph. D., Professor of Zoology, University of Kansas, Lawrence, Kan. (52). F

McClung, Robert K., D. Sc., Prof. of Physics, Mount Allison Univ., Sackville, N. B., Canada. (56). B

McClure, Geo. E., Missouri Botanical Garden, St. Louis, Mo. (53). G

McClure, S. S., 44–60 E. 23d St., New York City. (57).

McConnell, Wilbur Ross, State College, Pa. (57) F

McCormick, Florence Anna, Asst. Dept. Natural Science, Winthrop Normal and Industrial College, Rockhill, S. C. (55). F

McCormick, Rev. Samuel Black, D. D., LL. D., Chancellor Western Univ. of Pennsylvania, Allegheny City, Pa. (54).

McCourt, Walter Edw., Washington Univ., St. Louis, Mo. (57). **E**

*MacCracken, John Henry, Ph. D., LL. D., Syndic of New York University, New York, N. Y. (52). 1907. **I**

McCracken, Isabel, Stanford Univ., Cal. (54). **F**

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McCullough, John G., Hall Farm, No. Bennington, Vt. (57).

McCullough, Laurence Hugh, 5th Dist. Agric. School, Wetumpka, Alabama. (54). **CG**

McCune, M. Virginia, M. D., 506 West John St., Martinsburg, W. Va. (51). **K**

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*McCurdy, Charles W., Ph. D., 331 Witherspoon Bldg., Philadelphia, Pa. (35). 1895. **E F**

*MacCurdy, George Grant, Ph. D., 237 Church St., New Haven, Conn. (48). 1900. **H**

McCurdy, Hansford M., Alma College, Alma, Mich. (51). **F G**

McDermott, Rev. P. A., Roman Catholic Mission, Old Calabou, Nigeria, West Africa. (51). **E H I**

Macdonald, Benjamin J., Lock Box 704, Newburgh, N. Y. (50). **I**

McDonnell, Curtis C., Asst. Chemist Agric. Exper. Station, Clemson College, S. C. (51). **C**

*McDonnell, Prof. Henry B., College Park, Md. (40). 1893. **G**

*MacDougal, Daniel T., Carnegie Institution, Washington, D. C. (44). 1897. **G**

MacDougall, George R., 131 West 73d St., New York, N. Y. (49).

*MacDougall, Robert, Ph. D., Sedgwick Park, Bronx, New York, N. Y. (49). 1901. **H K**

McDowell, Edward Campbell, care The American Car and Foundry Co., 107 Walnut St., Berwick, Pa. (54). **D**

*McElfresh, William Edward, Williamstown, Mass. (53). 1906. **B**

McFadden, Prof. L. H., 40 Warder St., Dayton, Ohio. (32). **B C**

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*Mitchell, Prof. Henry Bedinger, Columbia University, New York, N. Y. (50). 1906. **A**

Mitchell, J. Pearce, Stanford University, Cal. (51). **C**

*Mitchell, S. Alfred, Ph. D., Columbia University, New York, N. Y. (52). 1906. **A B**

Mitchell, Walter Mann, 112 N. 34th St., Philadelphia, Pa. (54). **A**

Mitchell, William Francis, M. D., Lancaster, Mo. (51). **K**

Mixer, Chas. Adam, Civil Engineer, Engineer, Rumford Falls Power Co., Rumford Falls, Maine. (51). **D**

Mixer, Fred. K., 313 Delaware Ave., Buffalo, N. Y. (35). **E**

*Miyake, Kiichi, Ph. D., Doshisha College, Kioto, Japan. (51). 1903. **G**

*Moenkhaus, Wm. J., University of Indiana, Bloomington, Ind. (51). 1903. **F**

Mohler, George H., Fremont Normal School, Fremont, Neb. (53). **B F**

*Mohler, John F., Professor of Physics, Dickinson College, Carlisle, Pa. (44). 1905. **B**

Mohr, Louis, M. E., 32 Illinois St., Chicago, Ill. (50). **A D**

Mojonnier, Timothy, care of Helvetia Milk Condensing Co., Delta, Ohio. (52). **C**

*Moler, Geo. S., 408 University Ave., Ithaca, N. Y. (38). 1892. **B**

MOLERA, E. J., Civil Engineer, 606 Clay St., San Francisco, Cal. (50). **D**

Molitor, David, Civil and Consulting Engineer, 25 N. Park Ave., Fond du Lac, Wis. (51). **C D**

Molitor, Frederic Albert, care of Commonwealth Trust Co., St. Louis, Mo. (51). **D**

Momsen, Hart, Chief Clerk, Div. of Agric. Census Office, Washington, D. C. (50). **I**

Monfort, Wilson F., Chemist to Water Comm., 77 E. May St., St. Louis, Mo. (48). **C**

Monroe, Joseph E., Professor of Physics and Chemistry, Montana State Normal College, Dillon, Mont. (50). **B C**

Monroe, Paul, Ph. D., Prof. of History of Education, Teachers' College, Columbia Univ., New York, N. Y. (57). **I**

*Monroe, Will S., Professor of Psychology and Pedagogy, State Normal School, Westfield, Mass. (49). 1901. **H**

*Montague, William Pepperell, Adjunct Prof. of Philosophy, Columbia University, New York, N. Y. (54). 1906. **H I**

Montgomery, Edmund, M. D., Hempstead, Texas. (50). **F K**

Montgomery, Edmund B., M. D., 134 N. 8th St., Quincy, Ill. (51). **K**

*Montgomery, Henry, Ph. D., Univ. of Toronto, Ontario, Canada. (54). 1907. **E F H**

*Moody, Mrs. Anges Claypole, 1733 Bonté Ave., Berkeley, Cal (46). 1899. F

Moody, Mrs. Mary B., M. D., 154 E. Grand Ave., New Haven, Conn. (25). E F

*Moody, Robert O., M. D., Asst. Prof. Anatomy, Univ. of California, Berkeley, Cal. (35). 1892. F

*Moody, William Albion, Professor of Mathematics, Bowdoin College, Brunswick, Maine. (50). 1906. A

Mooers, Charles Ansel, Univ. of Tennessee, Knoxville, Tenn. (55). C

Mooney, James, Bureau of Ethnology, Washington, D. C. (54). H

Moore, Andrew Charles, Prof. Biol. and Geol., Univ. of S. C., Columbia, S. C. (54). E F

Moore, Mrs. A. H., Stanstead, P. Q., Canada. (32). H

*Moore, Burton E., University of Nebraska, Lincoln, Neb. (41). 1899. B

*Moore, Clarence B., 1321 Locust St., Philadelphia, Pa. (44). 1897. H

*Moore, Eliakim Hastings, Professor of Mathematics, University of Chicago, Chicago, Ill. (52). 1902. A

Moore, Ernest Carroll, Ph. D., Instructor in Philosophy, University of California, Berkeley, Cal. (50). I

*Moore, George Thomas, 229 S. High St., West Chester, Pa. 1901. G

*Moore, J. Percy, Ph. D., Instructor in Zoology, Biological Hall, Univ. of Pa., Philadelphia. (54). 1906. F

*Moore, J. W., M. D., Lafayette College, Easton, Pa. (22). 1874. ABD

*Moore, Philip North, Geologist and Mining Engineer, 611 Merchants-Laclede Bldg., St. Louis, Mo. (50). 1903. E

Moore, Robert, Consulting Engineer, 61 Vandeventer Place, St. Louis, Mo. (51). D

Moore, Stanley H., McKinley High School, St. Louis, Mo. (50). A D

Moore, V. A., Cornell Univ., Ithaca, N. Y. (57).

*Moore, Prof. Willis L., Chief of the Weather Bureau, U. S. Dept. Agriculture, Washington, D. C. (44). 1897. B

*Moorehead, Warren K., Curator of Museum, Phillips Academy, Andover, Mass. (38). 1890. H

Morgan, A. C., U. S. Dept. Agriculture, Washington, D. C. (54). F

Morgan, J. Frank, Agr. Exper. Station, Kingston, R. I. (55). C

*Morgan, H. A., Director Agric. Exper. Station, Knoxville, Tenn. (50). 1906. F

*Morgan, T. Hunt, Ph. D., Prof. of Zoology, Columbia University, New York, N. Y. (54). 1906. F

*Morgan, Wm. Conger, Ph. D., Instructor in Chemistry, University of California, Berkeley, Cal. (52). 1906. **C**

Morgan, Wm. F., Short Hills, N. J. (27).

Morgan, William Henry, President of The Morgan Engineering Co., Alliance, Ohio. (54). **D**

Morgan, Wm. Rogers, New Port, R. I. (57).

*Morley, Prof. Edward W., West Hartford, Conn. (18). 1876. **B C E**

Morrey, Charles B., Ohio State University, Columbus, Ohio. (48). **F**

*Morrill, Austin W., Ph. D., U. S. Dept. Agriculture, Washington, D. C. (54). 1906. **F**

Morrill, C. V., Department Zoölogy, Columbia University, New York, N. Y. (56). **F**

Morris, Edward Lyman, 360 E. 22d St., Flatbush, Brooklyn, N. Y. (52). **G**

Morris, Henry L., 16 Exchange Place, New York, N. Y. (49).

*Morris, John T., 876 Drexel Bldg., Philadelphia, Pa. (54). 1906.

Morris, Newbold, 52 E. 72d St., New York, N. Y. (49).

Morris, Russell Love, Professor of Civil and Mining Engineering, West Virginia State University, Morgantown, W. Va. (50). **D**

Morrison, Charles Edward, C. E., 431 West 117th St., New York City. (51). **D**

Morrison, Gilbert B., McKinley High School, St. Louis, Mo. (48). **B C I**

Morrison, Thomas, Diamond Bank Bldg., Pittsburg, Pa. (51). **D**

Morse, Prof. Albert P., Wellesley, Mass. (50). **F**

*Morse, E. S., Salem, Mass. (18). 1874. **F H**

*Morse, Fred. W., Prof. of Organic Chemistry, New Hampshire College, Durham, N. H. (51). 1906. **C**

Morse, Max W., College of City of New York, New York, N. Y. (51). **F**

Morse, Warner Jackson, Agric. Exper. Station, Orono, Me. (52). **G**

Morse, Willard S., Am. Smelting & Refining Co., 71 Broadway, New York City. (50). **C D E**

Morton, George L., Room 322, Patent Office, Washington, D. C. (52). **B D**

Morton, Henry Sam'l, 141 Broadway, New York City. (57).

Morton, Wm. James, M. D., 19 East 28th St., New York City. (57). **K**

Moseley, Edward Augustus, Secretary Interstate Commerce Commission, 1113 16th St. N. W., Washington, D. C. (56). **D I**

*Moseley, Edwin L., High School, Sandusky, Ohio. (34). 1902. **G**

*Moser, Jefferson F., Captain U. S. N., Retired, 74 Folsom St., San Francisco, Cal. (28). 1889. **E**

*Moses, Prof. Alfred J., Columbia University, New York, N. Y. (49). 1902. **E**

Mosher, Charles D., care of Mosher Water Tube Boiler Co., 1 Broadway, New York, N. Y. (53). **D**

Mosman, Alonzo T., 1609 Beverly Road, Brooklyn, N. Y. (51). **D**

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Motter, Murray Galt, M. D., 1841 Summit Ave., Lanier Heights, Washington, D. C. (51). **K**

*Motter, David M., Ph. D., Professor of Botany, University of Indiana, Bloomington, Ind. (50). 1901. **FGK**

*Moulton, Forest Ray, Ph. D., Instructor in Celestial Mechanics, University of Chicago, Chicago, Ill. (50). 1901. **A**

Moulton, Dudley, Bureau Entomology, U. S. Dept. of Agric., Washington, D. C. (57).

Moulton, W. H., care Cleveland Cliffs Iron Co., Ishpeming, Mich. (53). **D**

Mount, William D., M. E., General Superintendent, Mathieson Alkali Works, Saltville, Va. (51). **D**

Moyer, Harold N., M. D., 103 State St., Chicago, Ill. (51). **K**

Moyer, J. Ambrose, 214 Ocean St., Lynn, Mass. (54). **D**

Moyer, Lycurgus R., C. E., Montevideo, Minn. (50). **DG**

Muckenfuss, A. M., Professor of Chemistry, University of Mississippi, University, Miss. (52). **BC**

Mueller, Edward, Ph. D., Dept. of Chemistry, 1806 Locust St., St. Louis, Mo. (52). **C**

Muhlberg, William, M. D., 2617 Vine St., Cincinnati, Ohio. (57). **K**

Muir, John, Martinez, Cal. (22). 1900. **G**

Mulford, Miss A. Isabel, McKinley High School, St. Louis, Mo. (45). **G**

Mullan, W. G. R., President Boston College, Boston, Mass. (52).

*Mulliken, Samuel P., Mass. Inst. Technology, Boston, Mass. (43). 1899.

Muncaster, Stewart Brown, M. D., 907 Sixteenth St., N.W., Washington, D. C. (51). **K**

MUNN, JOHN P., 18 East 58th St., New York City. (57).

*Munro, John Cummings, M. D., Instructor in Surgery, Harvard Medical School, Boston, Mass. (50). 1906. **F K**

*MUNROE, PROF. C. E., George Washington University, Washington, D. C. (22). 1874. **C**

Munroe, John P., M. D., President N. C. Medical College, Davidson, N. C. (53). **K**

Munson, Joseph Theodore, Denison, Texas. (55). C E
Munson, T. V., Nurseryman, Denison, Texas. (51). G
Munson, W. H., Teacher of Zoology, State Normal School, Winona, Minn. (54). F
*Munson, Welton M., W. Va. Exper. Station, Morgantown, W. Va. (41). 1899. F G
*Munsterberg, Hugo, Harvard University, Cambridge, Mass. (47). 1898.
Murback, Louis, 950 Cass Ave., Detroit, Mich. (54).
*Murdoch, John, Public Library, Boston, Mass. (29). 1886. F H
Murdock, George J., Mechanician and Inventor, 33 Wallace Place, Newark, N. J. (50). A D
*Murlin, John R., 338 E. 26th St., New York, N. Y. (54). 1906. F
Murray, Benjamin Lindley, 770 St. Nicholas Ave., New York, N. Y. (57). C
*Murray, Daniel A., Ph. D., Dalhousie College, Halifax, N. S. (47). 1899. A
*Musser, John H., M. D., 1927 Chestnut St., Philadelphia, Pa (54). 1906. K
*Myers, Burton D., Assoc. Prof. and Head Dept. of Anatomy, Indiana Univ., Bloomington, Ind. (54). 1906. F K
Myers, Edward W., 375 Arcade Bldg., Greensboro, N. C. (49).
*Myers, Geo. W., Ph. D., Professor of Mathematics and Astromony. University of Chicago, Chicago, Ill. (46). 1899. A
Myers, Nathaniel, 135 Central Park West, New York City. (57).
*Myers, William S., Director Chilean Nitrate Works, 12 John St., New York, N. Y. (43). 1898. C
Mygatt, L. C., 241 West 77th St., New York City. (57).
Myres, John L., M. A., F. S. A., Christ Church, Oxford, England. (46). H
*Nachtrieb, Henry F., Professor of Animal Biology, University of Minnesota, Minneapolis, Minn. (53). 1905. F
*Nagle, James C., Professor of Civil Engineering, A. and M. College, College Station, Texas. (40). 1893. B D
Nancrede, Charles Beylard, Prof. of Surgery, University of Mich., Ann Arbor, Mich. (54). K
Nash, Arthur Douglas, 280 State St., Flushing, L. I. (57). C
*Nash, Geo. V., 2587 Bainbridge Ave., New York, N. Y. (47). 1906. G
*Nason, Frank L., West Haven, Conn. (36). 1888. E
*Neal, Herbert V., Knox College, Galesburg, Ill. (53). 1905. F
*Needham, Dr. James G., Lake Forest College, Lake Forest, Ill. (45). 1898. F
Needham, John B., Jr., Salem Public School, Salem, Mo. (54).

*Nef, J. U., University of Chicago, Chicago, Ill. (39). 1891. **C**
Neiler, Samuel Graham, Consulting and Designing Engineer, 1409 Manhattan Bldg., Chicago, Ill. (50). **D**
*Neill, Charles P., Chief of Bureau of Labor, Dept. of Commerce and Labor, Washington, D. C. (54). 1906. **I**
Neilson, John, Larchmont, New York. (57). **A**
Neilson, Walter Hopper, M. D., Ed. "Milwaukee Medical Journal," 114 Garfield Ave., Milwaukee, Wis. (51). **K**
*Nelson, Aven, Professor of Biology, University of Wyoming, Laramie, Wyoming. (50). 1903. **G**
*Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**
*Nelson, Edward William, U. S. Dept. of Agriculture, Washington, D. C. (54). 1906. **F**
Nelson, James Allen, 210 Mitchell St., Ithaca, N. Y. (55). **F**
Nelson, N. L. T., Instructor in Botany, Central High School, St. Louis, Mo. (53). **G**
Nelson, Wm., Rooms 7 and 8, Paterson Natl. Bank, Paterson, N. J. (42).
Nesmith, Henry E., Jr., 28 S[illegible]th St., New York, N. Y. (30). **B C F**
Neu, Daniel Alfred, 31[illegible]n St., Union Hill, N. J. (55). **G**
*Newcomb, H. T., National Metropolitan Bank Bldg., Washington, D. C. (47). 1898. **I**
*Newcomb, Prof. S., 1620 P St. N.W., Washington, D. C. (13). 1874. **A B**
*Newcombe, Frederick Charles, 1021 E. University Ave., Ann Arbor, Mich. (43). 1896. **G**
Newell, Frank Clarence, 434 Rebecca Ave., Wilkensburg, Pa. (51). **D**
*Newell, F. H., U. S. Reclamation Service, Washington, D. C. (40). 1893. **E**
*Newell, Wilmon, Secretary Crop Pest Commission, Baton Rouge, La. (53). 1906. **F G**
Newland, David Hale, Asst. State Geologist, Geological Hall, Albany, New York. (54). **E**
Newlands, James A., Chemist to State Board of Health, Middletown, Conn. (57). **C K**
*Newsom, John F., Stanford University, Cal. (44). 1903. **E**
*Newson, Henry Byron, Assistant Professor of Mathematics, University of Kansas, Lawrence, Kansas. (50). 1901. **A**
Nichols, Austin P., 4 Highland Ave., Haverhill, Mass. (37).
*Nichols, Ernest Fox, Columbia University, New York, N. Y. (41). 1893. **B**
*Nichols, E. L., Ph. D., Cornell University, Ithaca, N. Y. (28). 1881. **B C**

Nichols, Fred. R., Teacher of Physics, Richard T. Crane Manual Training High School, Chicago, Ill. (53). **B**

Nichols, M. Louise, Teacher Geography and Zoology, Phila. Normal School, 3207 Summer St., Phila., Pa. (54). **E F**

Nichols, Starr Hoyt, University Club, New York City. (57).

*Nichols, Walter S., 100 William St., New York, N. Y. (54). 1906. **A B**

Nichols, Wm. H., 25 Broad St., New York. (57). **C**

Nicol, Wm., School of Mining, Kingston, Ont. (57). **C E**

Nicola, Frank F., Farmers Bank Bldg., Pittsburg, Pa. (50). **D**

Niles, Robert Lossing, 20 Broad St., New York, N. Y. (47). **B C D**

*Niles, Prof. Wm. H., Mass. Inst. Tech., Boston, Mass. (16). 1874. **E**

*Nipher, Prof. Francis E., Washington University, St. Louis, Mo. (24). 1876. **B**

Noble, Alfred, 315 5th Ave., New York City. (57).

Noble, Levi F., 90 Wall St., New Haven, Conn. (54).

*Nolan, Edw. J., M. D., Acad. Nat. Sciences, Philadelphia, Pa. (29) 1890. **F**

Nolte, Lewis G., M. D., Senn's Block, Milwaukee, Wis. (51). **K**

Norris, Chas., M. D., 44 West 44th St., New York City. (57). **K**

Norris, Harry W., Professor of Zoology, Iowa College, Grinnell, Iowa. (53). **F**

*Norris, James F., Prof. of Chemistry, Simmons College, Boston, Mass. (54). 1906. **C**

Norris, Rollin, Supt. of Works, United Gas Impt. Co., 917 Pine St., Philadelphia, Pa. (54). **D I**

Norsworthy, Naomi, Tutor in Psychology, Columbia University, New York, N. Y. (54). **K**

Norton, A. Wellington, LL. D., Madison, S. Dak. (52). **I**

Norton, J. B., College of Agric., Cornell Univ., Ithaca, N. Y. (52). **G**

*Norton, J. B. S., College Park, Md. (47). 1899. **G**

*Norton, J. Pease, Yale Univ., New Haven, Conn. (57). 1907. **I**

*Norton, Thomas H., U. S. Consul, Chemnitz, Saxony, Germany. (35). 1887. **C**

*Norwood, Charles Joseph, Professor of Mining, State College of Kentucky, Lexington, Ky. (54). 1906. **E**

Notman, George, 99 John St., New York City. (57).

Nott, Charles Palmer, P. O. Box 281, Palo Alto, Cal. (50).

*Novy, Dr. Frederick G., Univ. of Michigan, Ann Arbor, Mich. (36). 1889. **C**

*Noyes, Prof. Arthur A., Mass. Inst. Technology, Boston, Mass. (45). 1897. **C**

Noyes, Isaac Pitman, 409 4th St. S. E., Washington, D. C. (49).
*Noyes, Wm. A., Bureau of Standards, Washington, D. C. (23). 1885. C
*Nunn, R. J., M. D., 5 York St., East, Savannah, Ga. (33). 1906. B H
Nutt, John Joseph, The Seminole, Broadway & 69th St., New York City. (57).
*Nuttall, Mrs. Zelia, Casa Alvarado, Coyoacan, D. F., Mexico. (35). 1887. H
*Nutting, Prof. Charles C., State University of Iowa, Iowa City, Iowa. (40). 1892. F
*Nutting, Perley Gilman, National Bureau of Standards, Washington, D. C. (53). 1906. A
Nylander, Olof O., R. F. D. 4, Caribou, Maine. (50). F
Nyswander, Reuben Edson, Jr., Ithaca, N. Y. (55). B
Oakes, F. James, 58 Stone St., New York, N. Y. (49).
Obear, G. B., Brown University, Providence, R. I. (54).
*Oberholser, Harry Church, U. S. Dept. Agriculture, Washington, D. C. (46). 1898. E F H
O'Byrne, Leo C., 996 Washington Boul., Chicago, Ill. (56). C D
Ochs, Adolph S., Times Bldg., Times Sq., New York. (57).
O'Connor, Haldeman, 13 North Front St., Harrisburg, Pa. (51). H
Odenbach, Frederick L., S. J., Director Meteorological Observatory, St. Ignatius College, Cleveland, Ohio. (54). B E F
O'Donoghue, Rev. Martin, Ammendale, Md. (53). K
Oestlund, Oscar W., Entomologist, State University, Minneapolis, Minn. (50). F
Oetinger, Dr. P. J., 621 Broadway, New York City. (57).
Ogden, Henry Vining, M. D., 141 Wisconsin St., Milwaukee, Wis. (51). F K
Ogden, Herbert Gouverneur, M. E., 2 Rector St., New York, N. Y. (50). B D
Ogden, Robert C., 784 Broadway, New York City. (57).
Ogden, Rollo, New York Evening Post, New York City. (57).
Ogilvie, Miss Ida Helen, Ph. D., Tutor in Geology, Barnard College, Columbia Univ., New York, N. Y. (51). E
Oglevee, Christopher S., Instructor in Biology, Lincoln College, Lincoln, Ill. (50). F
O'Harra, Prof. Cleophas Cisney, State School of Mines, Rapid City, So. Dak. (49).
*Ohlmacher, A. P., M. D., Director Biological Laboratory, Fred'k Stearns & Co., Detroit, Mich. (54). 1906. K
O'Kane, Henry, Wyandotte Bldg., Columbus, Ohio. (55). I
Okerström, Albert, M. D., Port Wing, Wis. (57). K

Oldberg, Oscar, Prof. of Pharmacy and Applied Phar. Chemistry Northwestern University Bldg., Chicago, Ill. (54). **C**

Oldfield, Anthony M., M. D., Harbor Beach, Mich. (51). **K**

Olds, George D., Dept. Mathematics, Amherst College, Amherst, Mass. (54). 1907. **A**

Oleson, Olaf M., Fort Dodge, Iowa. (53). **CG**

Olin, Stephen H., 34 Nassau St., New York City. (57).

*Oliphant, F. H., Geologist of South Penn. Oil Co., Oil City, Pa. (51). 1906. **E**

*Olive, Edgar W., University of Wisconsin, Madison, Wis. (48). 1903. **G**

*Oliver, Charles A., M. D., 1507 Locust St., Philadelphia, Pa. (54). 1905. **F**

Oliver, Wm. Letts, 101 Vernon St., Oakland, Cal. (56). **D**

Olmsted, John Charles Landscape Architect, 16 Warren St., Brookline, Mass. (50). **EI**

Olney, Louis Atwell, Professor of Chemistry, Lowell Textile School, 118 Riverside St., Lowell, Mass. (57). **C**

Olsen, Tinius, Manufacturer, 500 N. 12th St., Philadelphia, Pa. (51). **D**

Olsson-Seffer, Pehr, Ph. D., Consulting Scientist, Tropical Agric. and Forestry, Apartado 133 Bis, Mexico City, Mexico. (55). **CG**

OLYPHANT, R. M. JR., 16 East 52d St., New York City. (57).

O'Neill, Edmond, Univ. of California, Berkeley, Cal. (57). **C**

Onderdonk, Henry U., M. D., Buffalo, Wyo. (51). **GK**

Opdyke, William S., 20 Nassau St., New York, N. Y. (49).

*Orleman, Col. Louis H., Ph. D., Principal Peekskill Military Academy, Peekskll, N. Y. (47). 1900.

Orr, Mary Moore, 102 Remson St., Brooklyn, N. Y. (57).

Orr, William, Jr., 30 Firglade Ave., Springfield, Mass. (39). 1895. **BF**

*Ortmann, Arnold Edward, Ph. D., Curator of Invertebrate Zoology, Carnegie Museum, Pittsburg, Pa. (51). 1903. **E**

*Orton, Edward, Jr., The Normandie, Columbus, Ohio. (48). 1900. **E**

*Orton, W. A., Div. of Veg. Phys. and Path., U. S. Dept. Agriculture, Washington, D. C. (49). **G**

Osborn, Frederick A., Professor of Physics, University of Washington, Seattle, Wash. (50). **B**

*Osborn, H. L., Professor of Zoology, Hamline University, St. Paul, Minn. (52). 1906. **F**

*Osborn, Henry F., Columbia University, New York, N. Y. (29). 1883. **F**

Osborn, Herbert, Ohio State University, Columbus, Ohio. (32). 1884. F

Osborn, Wm. Church, 71 Broadway, New York City. (57).

*Osborne, George Abbott, Professor of Mathematics, Mass. Inst. of Technology, Boston, Mass. (50). 1903. A

Osborne, Loyall Allen, E. E., Mgr. of Works of Westinghouse Electric and Mfg. Co., Pittsburg, Pa. (50). D

*Osburn, Raymond Carroll, Department of Zoology, Columbia University, New York, N. Y. (50). 1906. F

Osgood, Alfred Townsend, M. D., 14 East 58th St., New York City. (57). K

Osgood, Joseph B. F., P. O. Box 212, Salem, Mass. (31).

*Osgood, Wilfred H., U. S. Department of Agriculture, Washington, D. C. (52). 1905. F

O'Shea, Prof. M. V., Secretary of the Society of College Teachers of Education, University of Wisconsin, Madison, Wis. (53). 1907. I

*Osmond, Prof. I. Thornton, State College, Pa. (33). 1889. A B C

O'Sullivan, Rev. Denis T., S. J., 761 Harrison St., Boston, Mass (40). A B

Othmann, Henry I., 200 West 56th St., New York, N. Y. (56).

*Ott, Isaac, 18 N. 4th St., Easton, Pa. (54). 1906. K

*Overton, James Bertram, Ph. D., Instructor in Botany, Univ. of Wisconsin, Madison, Wis. (52). 1906. G

Owen, Charles Lorin, Field Museum of Nat. History, Chicago, Ill. (50). 1902. H

*Owen, Prof. D. A., Franklin, Ind. (34). E

*Owen, Miss Juliette A., 306 N. Ninth St., St. Joseph, Mo. (50). 1906. F

Owen, Miss Luella Agnes, 306 N. Ninth St., St. Joseph, Mo. (47). E

Owens, William Gundy, Professor of Chemistry and Physics, Bucknell University, Lewisburg, Pa. (50). B C

Pack, Fred J., Prof. Geology and Mineralogy, Brigham Young College, Logan, Utah. (54). E

Packard, George Arthur, Metallurgist and Mining Engineer, 18 Lafayette St., Wakefield, Mass. (50). E

Paddock, Eugene H., 149 West 72d St., New York City. (57).

*Paddock, Wendell, Professor of Botany and Horticulture, Agricultural College, Fort Collins, Colo. (50). 1901. G

Page, Clarence V., Civil and Mining Engineer, P. O. Box 922, Butte, Montana. (51). D E

Page, Dr. Dudley L., 46 Merrimack St., Lowell, Mass. (33). F

Page, Edward D., 60 North St., New York. (57).

Page, Logan Waller, Department of Agriculture, Washington, D. C. (52). C

PAGE, MRS. NELLIE K., 46 Merrimack St., Lowell, Mass. (33). F

*Paine, Cyrus F., 242 East Ave., Rochester, N. Y. (12). 1874. AB

Paine, Ellery Burton, Prof. Physics and Electrical Engineering, N. C. College Agriculture and Mechanic Arts, West Raleigh, N. C. (54). BD

Paine, Paul McClary, West Point, N. Y. (53). E

*Paine, Robert Treat, President, Associated Charities of Boston, 6 Joy St., Boston, Mass. (50). 1903. I

Painter, Joseph H., U. S. National Museum, Washington, D. C. (54). G

*Palmer, Prof. Albert De Forest, Brown University, Providence, R. I. (47). 1900. B

*Palmer, Charles Skeele, Ph. D., Associate Editor, Engineering and Mining Journal, 637 Valley Rd., Upper Montclair, N. J. (50). 1901. C

Palmer, Dr. Edward, Botanical Div., U. S. Dept. Agriculture, Washington, D. C. (22). H

Palmer, Ezra, M. D., 1 Van Buren Hall, Trinity Court, Boston, Mass. (51). K

Palmer, Irving A., 319 W. 9th St., Pueblo, Colo. (52). C

Palmer, Thomas Waverly, Pres. Ala. Girls' Industrial School, Montwallo, Ala. (55). A

Palmer, Walter Keifer, Consulting Engineer, 401 New York Life Bldg., Kansas City, Mo. (47). BD

Paltsits, Hon. Victor Hugo, State Historian, Albany, N. Y. (51). H

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Reed, Howard Sprague, Bureau of Soils, Dept. Agriculture, Washington, D. C. (53). **G**
Reed, Hugh D., Ph. D., Instructor, Dept. of Neurology, Vertebrate Zoology and Physiology, Cornell University, Ithaca, N. Y. (49). 1906. **F**
Reed, Hon. James H., Amberson Ave., Pittsburg, Pa. (51).
*Reed, John O., 907 Lincoln Ave., Ann Arbor, Mich. (44). 1898. **B.**
*Rees, Prof. John K., Columbia University, New York, N. Y. (26). 1878. **A B E**
*Reese, Albert Moore, Ph. D., Prof. Zoology, W. Va. Univ., Morgantown, W. Va. (52). 1906. **F**
*Reese, Charles L., 1020 Jackson St., Wilmington, Del. (39). 1892. **C**
*Reese, Herbert M., 701 | Maryland Place, Columbia, Mo. (49). 1906. **B**
Reeves, Geo. I., Bur. Entomology, Washington, D. C. (57). **F**
*Reichmann, Fritz, Physical Laboratory, W. and L. E. Gurley, Troy, N. Y. (54). 1906. **B**

*Reid, Harry Fielding, Johns Hopkins University, Baltimore, Md. (36). 1893. B

*Reid, Hon. Whitelaw, 451 Madison Ave., New York, N. Y. (50) 1901. I

Reifsnyder, Samuel K., 705 Bond St., Asbury Park, N. J. (50). I

Reigart, John Franklin, 31 Euclid Ave., Yonkers, N. Y. (53). I

*Reighard, Jacob, Prof. of Zoology, Univ. of Michigan, Ann Arbor, Mich. (51). 1903. F

Reist, Henry G., Mechanical and Electrical Engineer, 5 South. Church St., Schenectady, N. Y. (50). D

*Remington, Prof. Joseph Price, 1832 Pine St., Philadelphia, Pa. (54). 1906. K

*Remsen, Ira, President Johns Hopkins University, Baltimore, Md. (22). 1875. C

Rennert, Rosina J., 366 West 120th St., New York City. (57).

Renninger, John S., M. D., Marshall, Minn. (31). CF

Reynolds, Dudley Sharpe, M. D., 304 W. Chestnut St., Louisville, Ky. (50). K

Reynolds, George, P. O. Box B, Salt Lake City, Utah. (44). H

Rhein, Meyer L., M. D., D. D. S., 38 E 61st St., New York, N. Y. (57). K

*Rhodes, James Ford, Author and Historian, 392 Beacon St., Boston, Mass. (50). 1903. I

*Rice, Edward L., A. B., Ohio Wesleyan University, Delaware, Ohio. (43). 1905. F

Rice, Edwin Wilbur, Jr., General Electric Co., Schenectady, N. Y. (50). D

Rice, Herbert A., Assistant Professor of Civil Engineering, University of Kansas, Lawrence, Kansas. (55). AD

*Rice, Martin Everett, Asst. Professor of Physics and Electrical Engineering, University of Kansas, Lawrence, Kans. (50). 1906. B D

*Rice, Prof. W. North, Wesleyan University, Middletown, Conn. (18). 1874. EF

Rich, Michael P., M. D., 50 W. 38th St., New York, N. Y. (40).

Richard, Montrose R., M. D., Box 5, Mobile, Ala. (51). K

*Richards, Prof. Charles B., 227 Edwards St., New Haven, Conn. (33). 1885. D

*Richards, Edgar, 341 W. 88th St., New York, N. Y. (31). 1886. C

*Richards, Herbert Maule, Ph. D., Instructor in Botany, Barnard College, Columbia University, New York, N. Y. (51). 1902. G

*Richards, Prof. Robert H., Mass. Institute of Technology, Boston, Mass. (22). 1875. **D**

*Richards, Mrs. Robert H., Mass. Institute of Technology, Boston, Mass. (23). 1878. **C**

*Richards, Prof. Theodore William, Harvard University, Cambridge, Mass. (47). 1899.

Richardson, Major Charles A., Canandaigua, N. Y. (50). **I**

*Richardson, Charles Henry, Ph. D., Syracuse Univ., Syracuse, N. Y. (47). 1906. **C E**

Richardson, Charles Williamson, M. D., 1317 Connecticut Ave. N. W., Washington, D. C. (49).

*Richardson, Clifford, 122 E. 34th St., New York, N. Y. (30). 1884. **C**

*Richardson, G. B., U. S. Geological Survey, Washington, D. C. (55). 1907. **E**

*Richardson, Miss Harriet, 1864 Wyoming Ave., Washington, D. C. (49). 1903. **F**

*Richardson, Mark Wyman, M. D., 90 Equitable Building, Boston, Mass. (51). 1903. **K**

Richardson, W. D., care Swift & Co., Chicago, Ill. (56). **C**

Richardson, Wm. D., P. O. Box 185, Fredericksburg, Va. (52). **C F**

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*Rickard, T. A., Editor of Mining and Scientific Press, 330 Market St., San Francisco, Cal. (50). 1906. **D E**

Ricker, Maurice, 2833 Brattleboro Ave., Des Moines, Iowa. (50) **F**

*Ricker, N. Clifford, Dean of the College of Engineering, University of Illinois, Urbana, Ill. (50). 1906. **D**

*Ricker, Percy Leroy, Department of Agriculture, Washington, D. C. (52). 1906. **G**

Ricketts, Louis D., Consulting Mining Engineer, Globe, Arizona. (50). **D E**

*Ricketts, Palmer C., President Rensselaer Polytechnic Institute, Troy, N. Y. (33). 1887. **A D**

*Ricketts, Prof. Pierre de Peyster, 104 John St., New York, N. Y. (26). 1880. **C D E**

Ricketts, Col. R. Bruce, Wilkesbarre, Pa. (33). **E**

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Riddle, Lincoln Ware; Ph. D., Instructor in Botany, Wellesley College, Wellesley, Mass. (52). **G**

Riddle, Lumina C., 160 West Fifth Ave., Columbus, Ohio. (48). **G**

Ries, Elias E., E. E., 116 Nassau St., New York, N. Y. (23). **BD**

*Ries, Heinrich, Ph. B., Ithaca, N. Y. (41). 1898. **E**

Riesman, David, M. D., 1624 Spruce St., Philadelphia, Pa. (51). **K**

*Rietz, Henry Lewis, University of Illinois, Urbana, Ill. (51). 1906. **A**

*Riggs, Norman Colman, Assoc. Prof. Mathematics, Armour Inst. of Tech., Chicago, Ill. (54). 1907. **A**

*Riggs, Robert Baird, Ph. B., Professor of Chemistry, Trinity College, Hartford, Conn. (50). 1901. **C**

Riker, Clarence B., Maplewood, N. J. (52). **F**

Riker, Samuel, 27 E. 69th St., New York, N. Y. (50).

Riley, Cassius M., Professor of Chemistry, Barnes Medical College and Barnes College of Pharmacy, St. Louis, Mo. (53). **C**

Riley, C. F. Curtis, Prof. Biology and Curator of Museum, State Normal School, Mankuto, Minn. (57).

*Riley, Isaac Woodbridge, Ph. D., Johns Hopkins Univ., Baltimore, Md. (52). 1903. **HI**

Riley, Mrs. Matilda E., Art Director, St. Louis Public Schools, Board of Education Building, St. Louis, Mo. (53).

Riley, William Albert, Ph. D., Asst. Prof. of Entomology, Cornell University, Ithaca, N. Y. (54). **F**

Rissmann, Otto, General Manager, Cockerill Zinc Co., Nevada, Mo. (50). **DE**

Ritchie, Craig D., Conveyancer, 414 N. 34th St., Philadelphia, Pa. (51).

*Ritter, William Emerson, Associate Professor of Zoology, University of California, Berkeley, Cal. (50). 1901. **F**

Roark, Ruric Nevel, Pres. Eastern Ky. State Normal School, Richmond, Ky. (54). **I**

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Robert, Henry Martyn, Brig-Gen., U. S. A., Retired, Owego. N. Y. (54) **DI**

Robert, Dr. J. C., A. and M. College, Agricultural College, Miss. (51).

Robert, Samuel, 906 Park Ave., New York City. (57).

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Roberts, H. L., Instructor in Biology, High School, Galesburg, Ill. (52). **F**

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Roberts, Thomas Paschall, Civil Engineer, 361 North Craig St., Pittsburg, Pa. (51). **D**

Roberts, Wm. F., 730 15th St., Washington, D. C. (52). **FI**

Robertson, Alice, Wellesley College, Wellesley, Mass. (54). **F**

*Robertson, Charles, Carlinville, Ill. (53). 1906. **F**

Robinovitch, Louis G., M. D., 28 West 126th St., New York City. (57). **K**

*Robinson, Benjamin Lincoln, Curator Harvard Herbarium, Cambridge, Mass. (41). 1893. **G**

*Robinson, Mrs. Daisy M. Orleman, M. D., 159 W. 49th St., New York, N. Y. (40). 1897. **FK**

*Robinson, Prof. Franklin C., Bowdoin College, Brunswick, Me. (29). 1889. **CD**

*Robinson, Otis Hall, Professor of Natural Philosophy, University of Rochester, Rochester, N. Y. (23). 1901. **AB**

Robinson, Samuel Adams, M. D., Covesville, Va. (51). **HIK**

Robinson, Sanford, C. E., E. M., 945 W. Jefferson St., Los Angeles, Cal. (50). **D**

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Robinson, Miss Winifred J., Instructor in Botany, Vassar College, Poughkeepsie, N. Y. (55). **G**

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*Rockwood, Elbert W., Professor of Chemistry and Toxicology, College of Medicine, State University of Iowa, Iowa City, Iowa. (50). 1906. **CK**

Roddy, H. Justen, Prof. of Geology and Geography, State Normal School, Millersville, Pa. (57). **E**

*Roe, Edward Drake, Jr., Professor of Mathematics, Syracuse University, Syracuse, N. Y. (50). 1906. **A**

Roessler, Franz, 39 High St., Perth Amboy, N. J. (39).

*Roever, William Henry, Mass. Inst. Technology, Boston, Mass. (53). 1906. **A**

Rogers, Miss Anne Fuller, 126 Newbury St., Boston, Mass. (52). **F**

Rogers, Chas. Gardner, Ph D., Syracuse University, Syracuse, N. Y. (57). **F**

Rogers, Howard J., Department of Education, Albany, N. Y. (52).

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Rolfs, Peter H., Dir. Exper. Station, Lake City, Fla. (41). 1899. G
Rollins, William Herbert, M. D., 250 Marlborough St., Boston, Mass. (50). BK
*Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. E
Roosevelt, W. E., P. O. Box 1222, New York City. (57).
*Root, Hon. Elihu, Secretary of State, Washington, D. C. (50). 1901. I
Rorer, James Birch, Bureau of Plant Industry, Washington, D. C. (51). G
*Rorer, Jonathan T., Ph. D., Central High School, Philadelphia, Pa. (47). 1906.
*Rosa, Edward Bennett, Bureau of Standards, Washington, D. C. (39). 1892. AB
*Rose, Joseph Nelson, U. S. National Museum, Washington, D. C. (52). 1905. G
*Rosenau, Milton J., M. D., Director Hygienic Laboratory, U. S. Public Health and Marine Hospital Service, Washington, D. C. (51). 1906. K
Rosenbloom, Jacob, B. S., care of Livingston Hall, Amsterdam and 115th Sts., New York City. (57). K
Rosenfeld, Arthur H., State Crop Pest Comm., Baton Rouge, La. (57). F
*Ross, Bennett Battle, Professor of Chemistry, Alabama Polytechnic Institute, Auburn, Ala. (45). 1906. C
*Ross, Denman Waldo, Ph. D., 24 Craigie St., Cambridge, Mass. (29). 1906.
Ross, W. A., 11 S. William St., New York. (57).
Rossbach, Jacob, 55–57 Frankfort St., New York City. (57).
*Rotch, A. Lawrence, Director of Blue Hill Meteorological Observatory, Hyde Park, Mass. (39). 1896. B
*Rotch, T. M., M. D., 197 Commonwealth Ave., Boston, Mass. (51). 1906. K
Roth, Filibert, University of Michigan, Ann Arbor, Mich. (39). F
Rothermel, John G., Superintendent, Wagner Free Institute of Science, Philadelphia, Pa. (53).
Rothermel, John J., Teacher of Physics, Eastern High School, Washington, D. C. (51). B
Rothschild, Jacob, Hotel Majestic, New York, N. Y. (50).
*Rotzell, W. E., M. D., 200 S. 40th St., Philadelphia, Pa. (45). 1906. F H
Rouse, B. Irving, 981 Lake Ave., Rochester, N. Y. (57). E

Rowe, Jesse Perry, Professor of Physics and Geology, University, of Montana, Missoula, Montana. (52). **BE**

*Rowlee, W. W., Prof. of Botany, Cornell Univ., Ithaca, N. Y. (41). 1894. **G**

Roy, Arthur J., C. E., Dudley Observatory, Albany N. Y. (50). **A**

Royce, Josiah, Harvard Univ., Cambridge, Mass. (57). **H**

Rucker, Miss Augusta, University of Texas, Austin. Texas. (51).

*Ruddick, William H., M. D., So. Boston, Mass. (51). 1906. **FK**

Rudisch, Julius, M. D., 39 E. 63d St., New York, N. Y. (57). **K**

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Rugan, H. F., Tulane University, New Orleans, La. (55). **D**

Ruger, Henry A., Prof. of Psychology, Colorado College, Colorado Springs, Colo. (54). **H K**

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*Running, Theodore R., Ph. D., Dept. of Engineering, Univ. of Michigan, Ann Arbor, Mich. (50). 1906. **A**

Rupp, August, A. B., College of City of New York, New York, N. Y. (35).

Ruppersburg, Miss Emma A. 842 So. High St., Columbus, O. (48). **B**

*Rusby, Henry H., M. D., 115 West 68th St., New York, N. Y. (36). 1890. **G**

Rusk, Glanville Y., M. D., N. Y. Pathological Institute, Wards Island, New York, N. Y. (54). **K**

Rusk, W. J., Dept. of Math. and Astronomy, Iowa College, Grinnell, Iowa. (57). **A**

*Russell, A. H., Lieut. Col. U. S. A., Ordnance Office, War Dept., Washington, D.C. (38). 1906. **D**

*Russell, Prof. H. L., University of Wisconsin, Madison, Wis. (41). 1894. **G**

*Russell, Henry Norris, 79 Alexander St., Princeton, N. J. (54). 1906. **A**

*Russell, James E., Dean of Teachers' College, West 120th St., New York, N. Y. (50). 1901. **HI**

Russell, Janet L., 329 W. 83d St., New York City. (57).

Russell, John B., Superintendent of Schools, Wheaton, Ill. (51). **C**

Russell, Thomas Hubbard, M. D., New Haven Hospital, 137 Elm St., New Haven, Conn. (54). **K**

Ruthven, Alex. G., Univ. Museum, Ann Arbor, Mich. (54). F
*Rutter, Frank Roy, Ph. D., U. S. Dept. Agriculture, Washington, D. C. (47). 1900. I
*Ryan, Harris J., Stanford University, Cal. (38). 1890. B
*Rydberg, Dr. Per Axel, N. Y. Botanical Garden, Bronx Park, New York, N. Y. (49). 1901. G
Sabine, Florence R., M. D., Johns Hopkins Med. School, Wolfe and Monument Sts., Baltimore, Md. (57). K
*Sabine, Wallace Clement, 40 Shepard St.. Cambridge, Mass. (47). 1900. B
*Sachs, B., M. D., 21 E. 65th St., New York, N. Y. (49). 1903. K
Sackett, Miss Eliza D., Cranford, N. J. (35).
Sackett, Robert L., C. E., Purdue Univ., Lafayette, Ind. (50). A
Sackett, Walter George, Instructor in Bacteriology Mich. Agric-Col., Agricultural College, Mich (52). F G
*Sadtler, Saml. P., Ph. D., LL.D., Consulting Chemist, N. E. corner Tenth and Chestnut Sts., Philadelphia, Pa. (51). 1903. C
*Saegmuller, G. N., 606 13th St. N. W., Washington, D. C. (38). 1891. A B
*Safford, Frederick Hollister, Ph. D., Univ. of Pennsylvania, Philadelphia, Pa. (54). 1906. A
Safford, William Edwin, Dept. Agriculture, Washington, D. C. (55). G
*Sage, John Hall, Portland, Conn. (23). 1906. F
St. John, Prof. Charles E., Dept. Physics and Astronomy, Oberlin College, Oberlin, Ohio. (46). 1900. B
*Sajous, Charles Euchariste de Médicis, No. 2043 Walnut St., Philadelphia, Pa. (54). 1906. K
Salant, William, M. D., 437 West 59th St., New York, N. Y. (56). K
Salathé, Frederick, Ph. D., care of Joseph H. Lobell, Casper, Wyo. (51).
Salisbury, Sam'l Henry, Jr., 16 Miller St., Seneca Falls, N. Y. (57). C
*Salisbury, Prof. R. D., Chicago University, Chicago, Ill. (37). 1890. B E
*Salmon, Dr. Daniel E., Univ. of Montevideo, Montevideo, Uruguay. (31). 1885. F
*Sampson, Alden, 2223 Atherton St., Berkeley, Cal. (54). 1906. F
Sander, Enno, Ph. D., 2801–2811 Lawton Ave., St. Louis, Mo. (27). C
Sanders, James G., U. S. Dept. Agriculture, Washington, D. C. (54). F
*Sanderson, E. Dwight, Agr. Exp. Sta., Durham, N. H. (50). 1903. F
Sando, Will J., care Allis-Chalmers Co., Milwaukee, Wis. (51). E

Sandsten, E. P., Prof. of Horticulture, Univ. of Wisconsin, Madison, Wis. (54).

Sanes, K. I., M. D., 1636 5th Ave., Pittsburg, Pa. (51). K

*Sanford, E. C., 24 Richards St., Worcester, Mass. (49). 1902. H I K

*Sanford, Fernando, Professor of Physics, Stanford University, Cal. (50). 1901. B

Sanger, Frank Dyer, M. D., 525 N. Charles St., Baltimore, Md. (57). K

*Sardeson, Frederick William, Ph. D., Instructor in Geology, University of Minnesota, Minneapolis, Minn. (50). 1906. E

Sargent, Ara Nathaniel, M. D., 116 Federal St., Salem, Mass. (51). K

*Sargent, Dudley Allen, M. D., Director of the Hemenway Gymnasium, Harvard University, Cambridge, Mass. (47). 1899. H

Sargent, Frederick Le Roy, 27 Everett St., Cambridge, Mass. (54). G

Sargent, Winthrop, Haverford, Pa. (54). D

Sarle, Clifton J., N. W. School of Mines, Socorro. N. W. (55). E

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Satterthwait, Alfred F., Clerk to State Zoologist, Harrisburg, Pa. (57). F

Satterthwaite, Thos. Edw., 7 E. 80th St., New York City. (57). K

*Saunders, A. P., Ph. D., Hamilton College, Clinton, N. Y. (48). 1900. C

*Saunders, Charles E., Ph. D., Central Experimental Farm, Ottawa, Canada. (41). 1895. G

Saunders, Edward W., M. D., 3003 Lafayette Ave., St. Louis, Mo. (51). K

*Saunders, F. A., Ph. D., Instructor in Physics, Syracuse University, Syracuse, N. Y. (48). 1906. B

Saunders, James, M. D., Lock Box 147, Orange, Texas. (52). K

*Saunders, William, LL.D., F. R. S. C., F. L. S., Canadian Experimental Farms, Ottawa, Canada. (17). 1874. F

Saunders, Wm. H., 1407 F St., N.W., Washington, D. C. (52). I

Savage, Thomas E., Illinois Geological Survey, Urbana, Ill. (52). E F G

*Savage, Watson L., M. D., Mamaroneck, N. Y. (51). 1902. K

*Saville, Marshall H., Amer. Mus. Nat. History, Central Park, New York, N. Y. (39). 1892. H

Sawtelle, William Otis, 29 Ware St., Cambridge, Mass. (57). A B

Sawyer, Edward, Civil and Mechanical Engineer, Newton, Mass. (51). D

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Scaife, William Lucien, 28th St., Pittsburg, Pa. (51). **B D**

*SCHAEBERLE, J. M., 502 Second St., Ann Arbor, Mich. (34). 1886. **A**

Schaeffer, Henri N. F., care of Montreal Cotton Co., Valleyfield, Canada. (46). **C**

*Schaffner, John H., Ohio State University, Columbus, Ohio. (48). 1899. **G**

Schaller, Waldemar T., U. S. Geological Survey, Washington, D. C. (53). **E**

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Schenck, Charles C., Ph. D., Lehigh Univ., S. Bethlehem, Pa. (51). **B**

Scherf, C. Harry, care of State Normal School, Fairmont, W. Va. (53). **F**

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Schiaffino, Mariano L., Chief Electrical Engineer, "Campania de Luz de Guadalajara," Belen 2, Apartado 260, Guadalajara, Mexico. (50). **D**

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*Schlesinger, Frank, The Observatory, Allegheny, Pa. (51). 1902. **A**

Schlichting, Emil, Analytical Chemist, 38 Cranberry St., Brooklyn, N. Y. (50). **C**

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*Schmeckebier, Lawrence Frederick, Ph. D., U. S. Geol. Survey, Washington, D. C. (50). 1902. **E I**

Schmid, Dr. H. Ernest, White Plains, N. Y. (25).

Schmitt, A. Emil, M. D., Independence Ave., Riverdale-on-Hudson, N. Y. (50). **K**

*Schmucker, Samuel Christian, Ph. D., Professor of Biology, Normal School, West Chester, Pa. (53). 1906. **F G**

*Schneider, Albert, Cal. College Pharmacy, Parnassus Ave., San Francisco, Cal. (54). 1906. **C**

Schneider, Edward Christian, Ph. D. Professor of Biology, Colorado College, Colorado Springs, Colo. (55). **F G**

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*Schober, Wm. Bush, Lehigh University, South Bethlehem, Pa. (52). 1905. **C**

Schobinger, John J., Morgan Park, Ill. (34). **B**

*Schöney, L., M. D., St. James Court, 143d St. and 7th Ave., New York, N. Y. (29). 1900. **F**

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Schuarty, Frederick W., 452 Madison Ave., Albany, N. Y. (57). **C**

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Schultz, Alfred R., U. S. Geological Survey, Washington, D. C. (57). **E**

Schultz, Carl H., 430–444 First Ave., bet. 25th and 26th Sts., New York, N. Y. (29).

*Schultz, Louis G., Oficiana Meterologica Argentina, Viamonte 640, Buenos Aires, Argentina. (52). 1907. **B**

*Schultze, Arthur, 4 West 91st St., New York, N. Y. (54). 1906. **A**

*Schurman, Jacob Gould, LL.D., President Cornell University, Ithaca, N. Y. (49). 1901.

Schwab, Dr. Sidney I., 4393 Westminster Place, St. Louis, Mo. (52). **K**

*Schwarz, E. A., U. S. Department of Agriculture, Washington, D. C. (29). 1895. **F**

*Schweitzer, Paul, Professor of Chemistry, State Univ. of Missouri, Columbia, Mo. (24). 1877. **B C**

Scofield, Carl S., Department of Agriculture, Washington, D. C. (52). **G**

Scott, Prof. Arthur William, St. David's College, Lampeter, S. Wales, England. (46). **A B**

*Scott, Charles F., Westinghouse Electric and Mfg. Co., Pittsburg, Pa. (48). 1900. **B**

Scott, John W., 36 John St., New York City. (57).

*Scott, W. M., U. S. Dept. Agriculture, Washington, D. C. (50). **F**

Scovel, Edward C., Rosebud, S. Dak. (52).

*Scovell, M. A., Director and Chemist, Agricultural Experiment Station, Lexington, Ky. (35). 1887. **C**

Scribner, Gilbert H., "Inglehurst," Yonkers, N. Y. (57).

Scripture, Arthur M., Principal of High School, New Hartford, N. Y. (51). **D**

*Scudder, Samuel H., Cambridge, Mass. (13). 1874. **F**

*Scull, Miss Sarah A., Smethport, Pa. (40). 1895. **H**

Seal, Alfred Newlin, Ph. D., Professor of Chemistry, Girard College, Philadelphia, Pa. (50). **B C**

*Seaman Arthur Edmund, Professor of Geology and Mineralogy, Michigan College of Mines, Houghton, Mich. (53). 1906. **E**

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Searle, Frederick Edwards, Detroit University School, Detroit, Mich. (52). **B**

*Searle, Rev. George M., Paulist Fathers, 415 West 59th St., New York, N. Y. (39). 1891. **A**

Sears, Frederick Edmund, St. Paul's School, Concord, N. H. (47). **C E**

Sears, Henry Francis, M. D., 8 Beacon St., Boston, Mass. (50).

*Seashore, Carl E., Univ. of Iowa, Iowa City, Iowa. (49). 1902. **H**

Seawell, Benjamin Lee, Teacher of Biology, State Normal School, Warrensburg, Mo. (50). **F**

Secor, William Lee, Academia, Ohio. (52). **C**

Sedgwick, Howard M., M. D., 512 Woolner Bldg., Peoria, Illinois. (52). **B C K**

*Sedgwick, Prof. William Thompson, Massachusetts Institute of Technology, Boston, Mass. (47). 1898. **F G K**

See, Horace, 1 Broadway, New York, N. Y. (34). **D**

See, James W., M. E., Reutschler Bldg., Hamilton, Ohio. (51). **D**

*See, Prof. T. J. J., Naval Observatory, Mare Island, Cal. (48). 1901. **A**

*Seelig, M. G., M. D., 3908 Olive St., St. Louis, Mo. (54). 1906. **K**

*Segerblom, Wilhelm, Professor of Chemistry, Phillips Exeter Academy, Exeter, N. H. (53). 1906. **C**

Seitz, Chas E., 100 William St., New York City. (57).

*Selby, Augustine Dawson, Agric. Exper. Station, Wooster, Ohio. (44). 1900. **G**

Seligman, Edwin R. A., 324 W. 86th St., New York City. (57).

Seligman, Isaac N., 21 Broad St., New York, N. Y. (49).

*Sellards, Elias Howard, State Geologist, Fla. State Geol. Survey, Tallahassie, Fla. (54). 1906. **E F**

*Sellers, James Freeman, Prof. of Chemistry, Mercer University, Macon, Ga. (50). 1906. **C**

Sellew, Timothy G., 462 Park St., Upper Montclair, N. J. (57).

*Serviss, Garrett P., 8 Middagh St., Brooklyn, N. Y. (52). 1906

Sessinghaus, Gustavus, E. M., Farmington, Mo. (50). **E**

Sever, George F., Electrical Engineer, Broadway and 117th St., New York, N. Y. (49). **B**

Seymour, George Steele, Special Examiner, Interstate Commerce Comm., Washington, D. C. (51). **B C**

*Seymour, Paul Henry, 245 East 61st St., Chicago, Ill. (44). 1896 **C**

Seymour, Thomas Day, Yale Univ., New Haven, Conn. (57).

Shafer, John A., Custodian of the Museums, N. Y. Botanical Garden. Bronx Park, New York, N. Y. (51). **G**

Shaffner, Samuel C., Supt. Electric Lighting Co., Mobile, Ala. (50). **C D**

Shamel, Archibald D., U. S. Dept. of Agriculture, Washington, D. C. (52). **G**

*Shantz, Homer Le Roy, Ph. D., Instructor in Botany, University of Missouri, Columbia, Mo. (50). 1903. **F G**

Share, William W., Ph. D., Prof. of Chemistry and Geology, Adelphi College, Brooklyn, N. Y. (57).

Sharpe, Benjamin F., Greenwich, N. Y. (50). **B.**

Sharp, Charles Cutler., C. E., Kimberly, W. Va. (50). **D E**

*Sharp, Dr. Clayton H., Electrical Testing Laboratory, 80th St. and East End Ave., New York, N. Y. (45). 1897. **B**

Sharp, Edward Affleck, M.D., Katonah, N. Y. (56). **K**

Sharpe, Richard W., State Normal School, River Falls, Wis. (51). **F**

Sharples, Philip Price, A. B., 22 Concord Ave., Cambridge, Mass. (47). **C**

*Sharples, Stephen P., 26 Broad St., Boston, Mass. (29). 1884. **C**

*Shattuck, Frederick C., M. D., Professor Clinical Medicine. Harvard Medical College, Boston, Mass. (50). 1901. **F K**

Shattuck, George Brune, M. D., Vassar College, Poughkeepsie, N. Y. (54). **K**

*Shattuck, George Burbank, Johns Hopkins University, Baltimore, Md. (47). 1899. **E K**

Shattuck, John D., 517 Market St., Chester, Pa. (54). **D**

*Shattuck, Samuel Walker, Professor of Mathematics, University of Illinois, Urbana, Ill. (50). 1902. **A**

*Shaw, Dr. Charles Hugh, Ursinus College, Collegeville, Pa. (52). 1906. **G**

Shaw, Edwin C., M. E., 104 Park St., Akron, Ohio. (50). **D**

Shaw, Henry Clay, C. E., Glenshaw, Pa. (51). **D**

Shaw, Henry Lyman, M. D., 19 Commonwealth Ave., Boston, Mass. (51). **K**

Shaw, Mrs. John C., 317 Convent Ave., New York City. (57)

*Shaw, Walter Robert, Ph. D., Campbell, Cal. (47). 1902. **F**

Shaw, Wilson A., Cashier, Merchants and Manuf. National Bank, Pittsburg, Pa. (50). I

*Shea, Daniel William, Prof. of Physics, Catholic University of America, Washington, D. C. (54). 1906. B

SHEAFER, A. W., Pottsville, Pa. (28).

*Shear, Cornelius L., U. S. Dept. Agriculture, Washington, D. C. (49). 1901. G

*Shearer, John Sanford, Instructor in Physics, Cornell University, Ithaca, N. Y. (52). 1906. B

*Shedd, John C., Prof. of Physics, Colorado College, Colorado Springs, Colo. (50). 1906. A B

*Shedd, Solon, Professor of Geology and Mining, Agricultural College, Pullman, Wash. (50). 1906. E

Shedlock, Alfred, Mech. Engineer, 45 Broadway, New York City. (57). D

Sheffield, George St. John, Twin Elms Farm, Attleborough, Mass. (50).

Sheldon, Edmund P., Sec'y. Oregon Lumber Mfgn. Assn., 265 Washington St., Portland, Oregon. (54). G

*Sheldon, John Lewis, Ph. D., Bacteriologist, W. Va. Agr. Exp. Station, Morgantown, W. Va. (50). 1903. G

Sheldon, Mrs. J. M. Arms, 18 W. Cedar St., Boston, Mass. (44). F

Sheldon, Ralph Edward, 46 Conant Hall, Cambridge, Mass. (66). F

*Sheldon, Samuel, Ph. D., Polytechnic Institute, Brooklyn, N. Y. (42). 1894. B

*Sheldon, Wilmon H., Ph. D., Princeton Univ., Princeton, N. J. (54). 1906. H I

*Shelton, Prof. Edward M., 2904 Franklin Ave., Seattle, Wash. (32). 1892. F

Shepard, Edward M., 44 Pierrepont St., Brooklyn, N. Y. (57).

SHEPHERD, MISS ELIZABETH, 253 W. 128th St., New York, N. Y. (39).

Shepherd, Frank I., Santa Maria, Cal. (48). C

Sheppard, John Frederick, Univ. of Michigan, Ann Arbor, Mich. (54). H K

Sheppard, Hon. Morris, Member of Congress, Texarkana, Texas. (51).

Shepperd, J. H., Dean and Vice Director, North Dakota Agric. College, Agricultural College, North Dakota. (54).

*Sherman, Henry Clapp, Instructor in Analytical Chemistry, Columbia University, New York, N. Y. (51). 1906. C

Sherman, Lewis, M. D., 448 Jackson St., Milwaukee, Wis. (50). F K

Sherwood, George H., American Museum of Natural History, New York, N. Y. (56).

Sherwood-Dunn, B., M. D., Easton, Pa. (51). K

Shidy, Leland P., Coast and Geodetic Survey Office, Washington, D. C. (52). G

*Shimek, Bohumil, Professor of Botany, State University of Iowa, Iowa City, Iowa. (52). 1903. E G

Shimer, Hervey Woodburn, Instructor in Geology, Massachusetts Institute of Technology, Boston, Mass. (53). E

*Shimer, Porter W., E. M., Ph. D., Easton, Pa. (38). 1889. C

Shinn, Charles Howard, Head Forest Ranger, Northfork, Cal. (50). F G

Shoemaker, Henry W., 37–43 Wall St., New York City. (57).

Shore, Albert Ferdinand, 209 Nassau Ave., Brooklyn, N. Y. (54). D

Short, R. L., Care D. C. Heath & Co., 378-388 Wabash Ave., Chicago, Ill. (55).

Shott, John A., Professor of Physics, Westminster College, New Wilmington, Pa. (53). B

Shreve, Forrest, Ph. D., Woman's College, Baltimore, Md. (57). G

Shropshire, Walter, M. D., Yoakum, Texas. (50). F K

Shryock, Wm. Knight, 21 North 7th St., Philadelphia, Pa. (54).

*Shull, George Harrison, Santa Rosa, Cal. (53). 1905. G

Shultz, Charles S., Hoboken, N. J. (31). F

Shurly, E. L., M. D., 32 Adams Ave., West, Detroit, Mich. (51). K

Shurtleff, Eugene, M. D., 73 Hancock St., Dorchester Dist., Boston, Mass. (52). K

*Shute, D. K., M. D., 1719 De Sales St. N.W., Washington, D. C. (50). 1906. F I K

*Shutt, Frank T., F. E. C., F. C. S., Dominion Experimental Farms, Ottawa, Canada. (47). 1898. C

*Sias, Solomon, M. D., Schoharie, N. Y. (10). 1874. K

Sickels, Ivin, M. D., College City of New York, New York, N. Y. (50). F K

Siebel, John E., 1424 Montana St., Chicago, Ill. (57).

Sieberg, W. H. I., Hotel Winthrop, 125th St. and 7th Ave., New York, N. Y. (57).

Siedenburg, Frederic, Professor of Physics, St. Louis University, Grand Ave. and Pine St., St. Louis, Mo. (53). B

*Sigerfoos, Chas. Peter, Prof. Zoology, University of Minnesota, Minneapolis, Minn. (54). 1906. F

*Sigsbee, Charles D., Rear Admiral, U. S. N., Metropolitan Club, Washington, D. C. (28). 1882. D E

*Silloway, Perley Milton, Principal Fergus Co. Free High School, Lewiston, Montana. (51). 1906. F

Silvester, Charles Frederick, Curator Morphological Museum and Assistant in Anatomy, Princeton University, 10 Nassau Hall, Princeton, N. J. (54). F

Silvester, Richard W., President Maryland Agricultural College, College Park, Md. (50). G

Simkhovitch, Dr. V. G., Columbia University, New York, N. Y. (54) I

*Simon, Dr. Wm., Catonsville, Md. (29). 1859. C

*Simonds, Frederic W., Professor of Geology, University of Texas, Austin, Texas. (25). 1888. E F

Simons, Miss Etoile B., Western College, Oxford, Ohio. (57). G

Simonson, Wm., 126 W. 9th St., Cincinnati, Ohio. (57). C

Simpson, John Crayke, M. D., 1738 15th St. N. W., Washington, D. C. (51). K

Simpson, Quintus Irvin, Palmer, Ill. (54). F H

Simpson, William Kelly, M. D., 952 Lexington Ave., New York. City. (57). K

Sinclair, Alexander Grant, M. D., Equitable Bldg., Memphis, Tenn. (52). K

Sinclair, Cephas Hempstone, Coast and Geodetic Survey, Washington, D. C. (53). A

Singer, George Park, Central State Normal School, Lock Haven, Pa. (50). B

Skiff, F. J. V., Director, Field Museum of Nat. History, Chicago, Ill. (43).

*Skinner, Aaron Nichols, U. S. Naval Observatory, Washington, D. C. (40). 1893. A

*Skinner, Charles Edward, Engineering Dept. Westinghouse Electrical & Manfg. Co., East Pittsburg, Pa. (54). D

*Skinner, Clarence A., Ph. D., University of Nebraska, Lincoln Neb. (48). 1903. B

Skinner, Edward H., 211, 212 Rialto Bldg., Kansas City, Mo. (57). K I

*Skinner, Henry, M. D., 716 N. 20th St., Philadelphia, Pa. (47). 1902. F K

Slade, Denison Rogers, Centre Harbor, N. H. (R. F. D.). (55). E

Slade, Elisha, Somerset, Mass. (29). F

Slagle, Robert Lincoln, Ph. D., Brookings, S. D. (50). C E

*Slichter, Charles S., Professor of Applied Mathematics, University of Wisconsin, Madison, Wis. (51). 1902. A

*Slingerland, Mark Vernon, Assistant Professor of Economic Entomology, Cornell University, Ithaca, N. Y. (50). 1901. F

Slipher, V. M., Lowell Observatory, Flagstaff, Arizona. (52). **A**
Sloan, Benson, B. 141 East 36th St., New York City. (57).
Slocum, Chas. E., M. D., Defiance, Ohio. (34). **F G H**
*Slocum, Frederick, Ph. D., Asst. Prof. Astronomy, Brown Univ., Providence, R. I. (47). 1906.
Slonaker, J. Rollin, Stanford University, Cal. (49). **F**
*Slosson, Edwin E., Associate Editor, The Independent, 130 Fulton St., New York, N. Y. (50). 1901. **C**
*Small, John Kunkel, N. Y. Botanical Garden, Bedford Park, New York, N. Y. (44). 1902. **G**
Smallwood, Miss Mabel Elizabeth, 6112 Ingleside Ave., Chicago, Ill. (52). **F**
*Smallwood, William Martin, Syracuse University, Syracuse, N. Y. (50). 1903. **E F**
Smeaton, Wm. Gabb, Univ. of Michigan, Ann Arbor, Mich. (57). **C**
Smillie, Thomas W., U. S. National Museum, Washington, D. C. (40). **F**
*Smith, Prof. Albert W., Case School of Applied Science, Cleveland, Ohio. (47). 1900. **C**
*Smith, Alexander, Ph. D., University of Chicago, Chicago, Ill. (40). 1892. **C**
Smith, Alice Maude, M. D., 327 North G St., Tacoma, Wash. (53). **K**
*Smith, Allen J., M. D., University of Pennsylvania, Philadelphia, Pa. (47). 1905. **H**
*Smith, Andrew H., M. D., 18 East 46th St., New York, N. Y. (54). 1906. **K**
Smith, Mrs. Annie Morrill, 78 Orange St., Brooklyn, N. Y. (49). **G**
Smith, Arthur George, Prof. Physics and Mechanics, State Univ, of Iowa, Iowa City, Iowa. (50). **A**
*Smith, Arthur Whitmore, Ph. D., University of Michigan, Ann Arbor, Mich. (44). 1906. **B**
Smith, Burnett, Skaneateles, N. Y. (54). **E**
*Smith, Prof. Charles J., 2035 Adelbert Road, Cleveland, Ohio. (32). 1885. **A B**
*Smith, Prof. Edgar F., University of Pennsylvania, Philadelphia, Pa. (33). 1891. **C**
*Smith, Erastus G., Ph. D., Director Beloit Sanitary Laboratory, Beloit, Wis. (34). 1887. **C**
*Smith, Ernest Ellsworth, 26 East 29th St., New York, N. Y. (43). 1898. **F K**
Smith, Ernest Reveley, B. S., Teacher of Physics, Syracuse High School, 349 Westcott St., Syracuse, N. Y. (56). **B**

*Smith, Erwin F., U. S. Dept. Agriculture, Washington, D.C. (34). 1890. G

Smith, Eugene, C. E., 317 Washington St., Hoboken, N. J. (50). D

*Smith, Prof. Eugene Allen, State Geologist, University, Ala. (20). 1877. CE

Smith, Frances G., Dr., Smith College, Northampton, Mass. (57). G

*Smith, Francis Henry, University Station, Charlottesville, Va. (54). 1906.

*Smith, Frank, University of Illinois, Urbana, Ill. (49). 1900. F

Smith, Franklin W., Mining Engineer, Bisbee, Ariz. (57). DE

Smith, Fred. W., Dept. Science, Northern Normal and Industrial School, Aberdeen, S. D. (54). F

*Smith, George Otis, U. S. Geological Survey, Washington, D. C. (52). 1906. E

Smith, H. Carlton, Harvard Medical School, Boston, Mass. (56). K

*Smith, Harlan I., Amer. Mus. Nat. History, Central Park, New York, N. Y. (41). 1896. H

*Smith, Harold B., Professor of Electrical Engineering, Polytechnic Institute, Worcester, Mass. (43). 1898. D

Smith, Harvey F., Attorney at Law, Clarksburg, W. Va. (50). I

Smith, Herbert Stearns Squier, Professor of Applied Mechanics, Princeton University, Princeton, N. J. (29). D

*Smith, Hugh M., Bureau of Fisheries, U. S. Dept. Commerce and Labor, Washington, D. C. (52). 1906. F

Smith, Huron H., Dendrologist, Field Museum, Chicago, Ill. (56). G

Smith, Miss J. Angelina, Hopedale, Mass. (45). E

Smith, J. C., 131 Carondelet St., New Orleans, La. (48).

Smith, Prof. J. F., President Commercial College, Dallas, Texas. (52). I

Smith, James Hervey, 5432 Ohio St., Austin Sta., Chicago, Ill. (40).

*Smith, Jared G., Hawaiian Experiment Station, Honolulu, T. H. (47). 1901. G

SMITH, MISS JENNIE M., 260 Watson Blvd., Allegheny City, Pa. (50). A F

*Smith, John B., Ph. D., Rutgers College, New Brunswick, N. J. (32). 1884. F

Smith, Joseph R., M. D., LL. D., Brig. Gen'l and Assistant Surgeon General, U. S. A., 2135 Spruce St., Philadelphia, Pa. (43).

Smith, Lee H., M. D., President Buffalo Society of Natural Science, 663 Main St., Buffalo, N. Y. (51). H

Smith, Leonard S., 939 Univ. Ave., Madison, Wis. (57). A
Smith, Leslie Brewster, 6024 Hurst St., New Orleans, La. (55). A B
SMITH, MISS MATILDA H., 40 Library Place, Alleghany City, Pa. (50). A
Smith, Matthew Mann, M. D., Austin, Texas. (50). F K
Smith, Middleton, 1616 19th St., N. W., Washington, D. C. (52).
Smith, Dr. Philip Sidney U. S. Geol. Survey, Washington, D. C. (47). E
*SMITH, Q. CINCINNATUS, M. D., 1055 Fifth St., San Diego, Cal. (26). 1881. K
Smith, R. I., State Entomologist, Atlanta, Ga. (54). F
Smith, S. MacCuen, M. D., 218 W. Chelten Ave., Germantown, Pa. (54). K
Smith, Thomas A., Professor of Mathematics and Physics, Beloit College, Beloit, Wis. (50). A B
Smith, T. Guilford, Civil Engineer, Regent University, State of New York, Buffalo, N. Y. (50). D
Smith, W. Hinckle, 511 Chestnut St., Philadelphia, Pa. (54).
Smith, Warren D., Actg. Chief Div. Mines, Bureau of Science, Manila, P. I. (57). E
*Smith, Warren Rufus, Instructor in Chemistry, Lewis Institute, Chicago, Ill. (52). 1906. C
SMITH, WM. ALEX., 412 Madison Ave., New York City. (57).
*Smith, William Benjamin, Professor of Mathematics, Tulane University, New Orleans, La. (50). 1901. A
*Smith, W. S. Tangier, Ph. D., Univ. of Nevada, Reno, Nev. (50). 1906. E
Smith, William T., M. D., Prof. of Physiology and Dean of Dartmouth Medical School, Hanover, N. H. (51). K
*Smock, Prof. John Conover, Trenton, N. J. (23). 1879. E
Smock, Ledru Pierson, M. D., 3330 Chestnut St, Philadelphia, Pa. (54).
Smyth, Ellison A., Jr., LL. D., Virginia Polytechnic Inst., Blacksburg, Va. (57) F
*Smyth, C. H., Jr., Princeton University, Princeton, N. J. (38). 1894. E
*Sneath, E. Hershey, Professor of Philosophy, Yale University, New Haven, Conn. (51). 1902. H
Snedaker, James Angus, Mining Engineer, 850 Equitable Bldg., Denver, Colo. (50). D
Sneve, Haldor, M. D., Lowry Arcade, St. Paul, Minn. (51). K
*Snow, Prof. Benjamin W., 518 Wisconsin Ave., Madison, Wis. (35). 1889. B

Snow, Charles Carleton, 1411 20th St. N.W., Washington, D. C. (52).
Snow, Elbridge G., 56 Cedar St., New York City. (57).
*Snow, F. H., LL. D., Professor of Natural History, University of Kansas, Lawrence, Kan. (29). 1881. **E F**
Snow, Laetitia Morris, State Normal School, Box 200, Farmville, Va. (57).
Snow, Walter B., 29 Russell Ave., Watertown, Mass. (53). **D**
Snyder, Fred. D., M. D., 10 Center St., Ashtabula, Ohio. (51). **E F H**
*Snyder, Prof. Harry, Agricultural College, University of Minnesota, Saint Anthony Park, Minn. (44). 1897. **C**
*Snyder, Prof. Monroe B., Philadelphia Astronomical Observatory, Philadelphia, Pa. (24). 1882. **A B**
*Snyder, Zachariah Xenophon, President State Normal School, Greeley, Colo. (50). 1907. **F**
Solley, Fred P., M. D., 114 East 60th St., New York City. (57). **K**
*Sollmann, Torald, M. D., Professor of Pharmacology and Materia Medica, Medical College, Western Reserve University, Cleveland, Ohio. (52). 1906. **K**
Solyom, Herbert Louis, Room 325, Patent Office, Washington, D. C. (55). **A B**
*Soper, George A., Ph. D., 29 Broadway, New York, N. Y. (46). 1907. **C**
Sondern, Frederic E., M. D., 200 West 56th St., New York City. (57). **K**
Sooysmith, Chas., 71 Broadway, New York City. (57). **D**
*Soule, R. H, 1571 Beacon St., Brookline, Mass. (33). 1886. **D**
*Soule, William, Ph. D., Mount Union Coll., Alliance, Ohio. (33).
Southall, James P. C., Professor of Physics, Alabama Polytechnic Institute, Auburn, Ala. (51). **B**
Souvielle, Mathieu, M. D., Box 355, Jacksonville, Fla. (36). **B E F**
Souvielle, Mrs. Mathieu, Box 355, Jacksonville, Fla. (24). **A B F**
*Spalding, Frederick P., Professor of Civil Engineering, Univ. of Missouri, Columbia, Mo. (46). 1899. **D**
*Spalding, Volney M., Ph. D., 312 E. 4th St., Tucson, Arizona. (51). 1902. **G**
Spangler, Harry Allen, M. D., Carlisle, Pa. (51). **K**
*Spaulding, Edward G., Ph. D., College of the City of New York, New York, N. Y. (50). 1905. **I**
Spaulding, Perley, Bureau Plant Industry, Dept. Agriculture, Washington, D. C. (52). **G**
Spayd, Henry Howard, Superintendent of Schools, Minersville, Pa. (52). **B E K**

Spear, Gen. Ellis, 1601 Laurel Ave., Mt. Pleasant, Washington, D. C. (52). **D**

*Spencer, Arthur Coe, U. S. Geological Survey, Washington, D. C. (52). 1905. **E**

*Spencer, Prof. J. W., 1718 21st St. N.W., Washington, D. C. (28). 1882. **E**

Spenser, Lorillard, Mrs., 107 East 17th St., New York City. (57).

*SPENZER, JOHN G., M. D., 716 Rose Bldg., Cleveland, Ohio. (37). 1895. **C**

Sperry, Elmer A., Electrical Engineer, 366–388 Massachusetts Ave., Buffalo, N. Y. (51). **D**

*Speyers, Clarence Livingston, Associate Professor Chemistry, Rutgers College, New Brunswick, N. J. (50). 1901. **C**

Spiegelhalter, Dr. Joseph, 2166 Lafayette Ave., St. Louis, Mo. (47). **E**

*Spillman, Wm. Jasper, U. S. Dept. of Agr., Washington, D. C. (52). 1905. **G**

*Spinney, Prof. L. B., Iowa State College, Ames, Iowa. (42). 1897. **B**

*Spitzka, Edward Anthony, M.D., Prof. General Anatomy, Jefferson Medical College, Philadelphia, Pa. (54). 1906. **H**

Spofford, Paul N., P. O. Box 1667, New York, N. Y. (36).

Spohn, Arthur Edward, M. D., Corpus Christi, Texas. (50). **F K**

Spooner, Chas. S., Agricultural Exp. Station, Durham, N. H. (57). **F**

SPRAGUE, C. H., Malden, Mass. (29).

Sprague, Leonard P., M. D., Mary Fletcher Hospital, Burlington, Vt. (57). **G**

*Sprague, Robert James, Knox College, Galesburg, Ill. (53). 1906. **I**

Sprigg, Wm. Mercer, M. D., 1015 16th St., N.W. Washington, D. C. (52). **K**

*Springer, Dr. Alfred, 312 E. 2d St., Cincinnati, Ohio. (24). 1880. **C**

SPRINGER, HON. FRANK, East Las Vegas, N. M. (57).

*Springsteen, Harry W., Asst. Prof. Physics, Western Reserve Univ., Cleveland, Ohio. (49). 1906. **A B**

Squibb, Charles F., Bernardsville, N. J. (43).

Squibb, Edward Hamilton, M. D., 148 Columbia Heights, Brooklyn, N. Y. (41). **F K**

*Squier, Major George Owen, U. S. A., Signal School, Ft. Leavenworth, Kans. (54). 1906. **B**

Stackpole, Miss Caroline E., Teachers College, Columbia Univ., New York, N. Y. (53). **B C F G**

*Stahley, George D., M. D., Gettysburg, Pa. (47). 1907. **F G**

Stair, Leslie Dalrymple, 114 W. Maryland St., Indianapolis, Ind. (52). G

Stanley, William, Great Barrington, Mass. (50).

*Stanley-Brown, Joseph, Cold Spring Harbor, L. I., N. Y. (52). 1906.

STANTON, FRANK MCMILLAN, E. M., Agent of Atlantic, Baltic and Central Mining Co's. Atlantic Mine, Mich. (51). D E

Stanton, John R., 15 William St., New York, N. Y. (49).

Stanton, Robert Brewster, Civil and Mining Engineer, 66 Broadway, New York, N. Y. (51). D

*Stanton, Timothy W., U. S. Geological Survey, Washington, D. C. (50). 1902. E

*Starr, Frederick, Ph. D., University of Chicago, Chicago, Ill. (36). 1892. E H

*Starr, M. Allen, M. D., 5 West 54th St., New York, N. Y. (50). 1901. K

Starrett, M. G., 349 W. 85th St., New York, N. Y. (49).

Stauffer, Clinton R., Ohio State Univ., Columbus, Ohio. (57). E

Stauffer, Rev. Thomas F., 200 11th St., Sioux City, Iowa. (51). I

Stearns, Guy Beckley, M. D., 119 W. 82d St., New York, N. Y. (54). I K

*Stearns, H. D., Monrovia, Cal. (53). 1906. B

*Stearns, Robert E. C., Ph. D., 1025 East Eighteenth St., Los Angeles, Cal. (18). 1874. F

Stearns, Theron C., M. D., Consulting Chemist, 44 Montgomery St., Jersey City, N. J. (49).

Stearns, Thomas B., Mining Engineer, 1720 California St., Denver, Colo. (50). D E

Stebbins, Miss Fannie A., 480 Union St., Springfield, Mass. (44). F G

Steele, Warren M., Prof. of Philosophy, Furman Univ., Greenville, S. C. (57). K

Steer, Justin, M. D., Medical Department, Washington University, St. Louis, Mo. (50). F K

STEERS, JAMES R., 101 Park Ave., New York City. (57).

*Steiger, George, Chemical Laboratory, U. S. Geol. Survey, Washington, D. C. (40). 1901. B C E

Stein, John B., M. D., 126 W. 70th St., New York City. (57). K

Stein, Dr. Simon G., Muscatine, Iowa. (43).

Steinbach, Lewis W., M. D., 1309 N. Broad St., Philadelphia, Pa. (51). K

*Steinmetz, Charles Proteus, General Electric Co., Schenectady, N. Y. (40). 1895. B

Steinway, Fred T., 15 East 53rd St., New York, N. Y. (56).

*Stejneger, Leonhard, Curator of Dept. of Reptiles, U. S. Nationa Museum, Washington, D. C. (40). 1892. F

Stellwagen, Thos. C., M. D., Prof. Physiology, Philadelphia Dental College, 1328 Chestnut St., Philadelphia, Pa. (51). K

Stephens, Henry Matthew, Professor of Biology, Dickinson College, Carlisle, Pa. (50). F G

Stephens, Roswell P., Wesleyan Univ., Middletown, Conn. (57). A

Stephens, Thomas C., Morningside College, Sioux City, Iowa. (57). F

*Stephens, W. Hudson, Lowville, N. Y. (18). 1874. E H

Stephenson, Lloyd William, Maryland Geol. Survey, Baltimore, Md. (56). E

Stern, Philip Kossuth, Consulting Mechanical and Electrical Engineer, 521 W. 182d St., New York, N. Y. (50). B D

Sternberg, Charles Hazelius, Lawrence, Kansas. (50). E F

*Sternberg, Gen. George M., M. D., LL. D., U. S. A., 2144 California Ave. N. W., Washington, D. C. (24). 1880. F

Sternberger, Edwin, M. D., 43 East 60th St., New York City. (57). K

Sterne, Albert E., M. D., "Norways," Indianapolis, Ind. (51). K

Stetson, Francis Lynde, 15 Broad St., New York City. (57).

Stetson, George R., 1441 Mass. Ave. N. W., Washington, D. C. (49). H I

Stevens, Cyrus Lee, M. D., Secy. of the Medical Society of the State of Pa., Athens, Pa. (51). K

Stevens, Edward Lawrence, Associate City Superintendent of Schools, 59th St. and Park Ave., New York, N. Y. (52).

*Stevens, Frank L., Ph. D., Prof. of Biology, College of Agric. and Mech. Arts, West Raleigh, N. C. (44). 1899. G

Stevens, Frederick W., Department of Physics, Lake Forest University, Lake Forest, Ill. (50). B

Stevens, George T., M. D., 22 East 46th St., New York, N. Y. (28). B F

Stevens, James Franklin, M. D., 1136 O St., Lincoln, Neb. (50). F H K

*Stevens, James S., The University of Maine, Orono, Me. (48). 1900. B

Stevens, Nettie Maria, Instructor Experimental Morphology, Bryn Mawr College, Bryn Mawr, Pa. (54). F G K

Stevens, Miss Romiett, 520 Clinton St., Hudson, N. Y. (54). H

*Stevens, Prof. W. LeConte, Washington and Lee University, Lexington, Va. (29). 1882. B

Stevenson, Francis L., International Harvester Co., 7 Monroe St., Chicago, Ill. (47). D

*Stevenson, Prof. John J., University Heights, New York, N. Y. (36). 1888. E

*Stevenson, Mrs. Matilda Coxe, Zuni, N. M. (41). 1893. H
Stevenson, Wm. H., Professor of Soils, Iowa State College, Ames, Iowa. (55). C
Stewart, Alonzo Hamilton, M. D., Asst. Bacteriologist, Bureau of Health, City Hall, Philadelphia, Pa. (54). K
*Stewart, Colin Campbell, Associate Prof. of Physiology, Dartmouth Medical College, Hanover N. H. (54). 1906. K
Stewart, Douglas, Assistant to Director Carnegie Museum, Pittsburg, Pa. (50). E
Stewart, Francis Laird, Murrysville, Pa. (51). G
*Stewart, Fred. Carlton, Botanist, N. Y. Agric. Exper. Station, Geneva, N. Y. (44). 1901. G
*Stewart, George Walter, Professor of Physics, University of North Dakota, Grand Forks, N. Dak. (52). 1906. B
Stewart, James Henry, Director of W. Va. Agric. Exper. Station, Morgantown, W. Va. (50). E
Stewart, Louis B., Prof. Surveying and Geodesy, Univ. of Toronto, Toronto, Canada. (57). A
*Stewart, Oscar M., Assist. Professor of Physics, University of Missouri, Columbia, Mo. (46). 1900. B
Stewart, Robert W., M. D., The Oritz, Cincinnati, Ohio. (51). K
Stewart, Wm. R., 31 Nassau St., New York City. (57).
Stickney, Gardner P., 200 Knapp St., Milwaukee, Wis. (44). 1901. H
Stickney, Malcom Enos, Instructor in Botany, Denison University, Granville, Ohio. (53). G
*Stieglitz, Dr. Julius, University of Chicago, Chicago, Ill. (39). 1895. C
Stigall, Bennett Merriman, Director, Dept. of Biology, Manual Training High School, Kansas City, Mo. (53). G
*Stiles, Charles Wardell, Ph. D., Hygienic Laboratory, U. S. Public Health and Marine Hospital Service, Washington, D.C. (40). 1892. F
Still, George A., 603 W. Scott St., Kirksville, Mo. (50). C
Stillhamer, Arthur G., 412 E. Chestnut St., Bloomington, Ill. (50). B
Stillman, Ernest Goodrich, 9 East 72d St., New York City. (57). E
Stillman, Prof. John M,. Stanford University, California. (41).
Stillman, Wm. O., M. D., 287 State St., Albany, N. Y. (28). K
Stillwell, Albert G., 36 Gold St., New York City. (57). C
*Stillwell, Lewis Buckley, 100 Broadway, New York, N. Y. (50). 1906. B D
*Stine, Prof. W. M., Swarthmore College, Swarthmore, Pa. (37). 1900. A C

Stockard, Chas. R., Columbia University, New York, N. Y. (52). F
*Stockton, Charles G., M. D., 436 Franklin St., Buffalo, N. Y. (51). 1906. K
*Stockwell, John N., 2348 E. 40th St., Cleveland, Ohio. (18). 1875. A
Stoddard, George Howland, M. E., 197 Beacon St., Boston, Mass. (51). D
STOECKEL, CARL, Norfolk, Conn. (52). A E
*Stokes, Anson Phelps, 100 William St., New York, N. Y. (50). 1905. I
*Stokes, Henry Newlin, Ph. D., Bureau of Standards, Washington, D. C. (38). 1891. C E
*Stone, Alfred H., 201 A St. S.E., Washington, D. C. (51). 1905. I
*Stone, George E., Professor of Vegetable Pathology and Physiology, Massachusetts Agricultural College, Amherst, Mass. (48). 1902. G
*Stone, Miss Isabelle, Ph. D., 3352 Indiana Ave., Chicago, Ill. (50). 1906. B
Stone, J. I., 100 William St., New York City. (57).
*Stone, John S., Riverbank Court, Cambridge, Mass. (54). 1906. B
Stone, Julius F., Columbus, Ohio. (48).
Stone, Lincoln R., M. D., Newton, Mass. (31).
Stone, Mason A., 61 Pine St., New York, N. Y. (49).
*Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Charlottesville, Va. (24). 1876. A
Stone, Ralph Walter, U. S. Geological Survey, Washington, D. C. (57). E
*Stookey, Lyman Brumbaugh, Ph. D., University of Southern California, Los Angeles, Cal. (53). 1906. K
*Storey, Thomas Andrew, M. D., Asst. Prof. of Physical Instruction, College of City of New York, New York City. (52). 1906.
Storms, Albert Boynton, President Iowa State College, Ames, Iowa. (54). I
Storrs, Lucius S., Expert and Engineer of Tests, N. Y. N. H. & H. Railroad Co., New Haven, Conn. (51). E
*Story, Prof. Wm. E., Clark University, Worcester, Mass. (29). 1881. A
Stose, George W., U. S. Geological Survey, Washington, D. C. (52). E I
*Stowell, Prof. T. B., Potsdam, N. Y. (28). 1885. F
*Stradling, George F., Northeast Manual Training School, Philadelphia, Pa. (41). 1900. B
Stramler, A. P., Assayer to the Chitas Mining Co., Stephenville, Texas. (56). C
Strange, William R., 1643 Octavia St., New Orleans, La. (55). K

*Stratton, Samuel W., Bureau of Standards, Washington, D. C. (52). 1906.

Strause, H. P., 55–57 West 26th St., New York City. (57).

Strauss, Frederick M., 31 West 69th St., New York City. (57).

Strauss, Joseph, Lt.-Commander, U. S N., U. S. S. Arkansas, care Postmaster, New York, N. Y. (54). **D**

Streeter, Miss Stella G., Teacher of Botany, Trenton High School, Trenton, N. J. (54). **G**

*Stringham, Irving, Professor of Mathematics, University of California, Berkeley, Cal. (51). 1906. **A I**

Strock, John Roy, 337 N. Hanover St., Carlisle, Pa. (54). **B C**

Stromsten, Frank A., Instructor in Zoology, State University of Iowa, Iowa City, Iowa. (52). **F**

Strong, Edwin A., Department of Physics and Chemistry, State Normal School, Ypsilanti, Mich. (46). **B**

Strong, Frederick F., M. D., 532 Columbus Ave., Boston, Mass. (47). **B C K**

Strong, Frederick G., Box 959, Hartford, Conn. (50). **D**

*Strong, Oliver S., Columbia University, New York, N. Y. (52). 1903. **K**

*Strong, Reuben Myron, Ph. D., Department of Zoology, University of Chicago, Chicago, Ill. (51). 1906. **F**

Strong, Richard P., Bureau of Science, Manila, P. I. (55). **F**

*Strong, Wendell M., care of Mutual Life, 32 Nassau St., New York, N. Y. (44). 1899. **A B**

Strong, William Walker, Mechanicsburg, Pa. (54). **B**

Stuart, William, Professor of Horticulture, University of Vermont, Burlington, Vt. (52). **G**

Stubbs, Joseph Edward, President, Nevada State University, Reno, Nev. (54).

*Stubbs, W. C., Ph. D., 1033 Carondelet Str., New Orleans, La. (40). 1901. **F**

*Sturgis, Wm. C., 28 E. Columbia St., Colorado Springs, Colo. (40). 1892. **G**

Sturtevant, Edward, St. George's School, Newport, R. I. (57).

Sullivan, John J., M. D., 51 Passaic Ave., Passaic, N. J. (53). **K**

Sullivan, John Magruder, Ph. D., Professor of Chemistry, Millsaps College, Jackson, Miss. (56). **C**

Sullivan, Lucien Norris, Hacienda Loreto, Pachuca, Hidalgo, Mexico. (54). **D**

*Sullivan, Michael Xavier, Instructor in Physiology, Brown University, Providence, R. I. (55). 1907. **K**

Summa, Hugo, M. D., Professor of Medicine, St. Louis University, 2249 St. Louis Ave., St. Louis, Mo. (53). **K**

*Summers, Henry E., Professor of Zoology, State College, Ames Iowa. (50). 1906. F

Summers, Joseph, 107 S. 6th St., Columbia, Mo. (51). B

*Sumner, Francis B., Ph. D., Instructor in Natural History, College of the City of New York, New York, N. Y. (51). 1906. F

Sunderland, Chas. H., Rutherford, N. J. (57).

*Surface, Frank Macy, Biological Hall, Univ. of Pennsylvania, Philadelphia, Pa. (53). F

*Surface, Harvey Adam, Harrisburg, Pa. (50). 1906. F

*Sutton, William John, Geologist, Esquimalt and Nanaimo Ry Co., Victoria, B. C. (50). 1906. E

*Swain, Prof. Geo. Fillmore, Massachusetts Institute of Technology, Boston, Mass. (52). 1906. D

Swain, Joseph, Swarthmore College, Swarthmore, Pa. (54).

Swartzell, Karl D., 308 West 8th Ave., Columbus, Ohio. (48). 1906. A

Sweat, Mrs. L. D. M., The Connecticut, Washington, D. C. (52).

*Swensson, Emil, C. E., 5511 Hays St., Pittsburg, Pa. (51). 1906. D

*Swezey, Goodwin D., Professor of Astronomy and Meteorology, University of Nebraska, Lincoln, Neb. (50). 1906. A

Swingle, Walter T., U. S. Dept. Agriculture, Washington, D. C. (40). G

Swope, Gerard, Manager of the Western Electric Co., 810 Spruce St., St. Louis, Mo. (51). B D

*Symons, Thomas Baddeley, State Entomologist, College Park, Md. (54). 1906. F

Sylvester, A. H., U. S. Geological Survey, Washington, D. C. (57). E

Taber, G. Major, 508 Laughlin Bldg., Los Angeles, Cal. (51). E

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*Taff, Joseph Alexander, U. S. Geological Survey, Washington, D. C. (54). 1906. E

TAFT, ELIHU B., Burlington, Vt. (36). H

Takamine, Jokichi, 45 Hamilton Terrace, New York City. (57). C

*Tainter, Charles Sumner, 1335 Kalmia St., San Diego, Cal. (29). 1881. A B D

Tainter, Frank Stone, Civil Engineer, Far Hills, N. J. (51). D

*Talbot, Arthur N., Professor of Municipal and Sanitary Engineering, University of Illinois, Urbana, Ill. (51). 1906. D

Talbot, Eugene Solomon, 103 State St., Chicago, Ill. (54).

*Talbot, Henry P., Mass. Institute of Technology, Boston, Mass. (44). 1896. C

Talbot, Miss Marion, LL. D., The University of Chicago, Chicago, Ill. (54). **C K**

*Talbot, Miss Mignon, Mount Holyoke College, South Hadley, Mass. (51). 1906. **E**

Talbott, Mrs. Laura Osborne, The Lenox, 1523 L St. N.W., Washington, D. C. (36). **F G I**

Talcott, J. Frederick, 60 West 87th St., New York City. (57).

*Tallman, William Duane, Professor of Mathematics, State College, Bozeman, Mont. (50). 1906. **A**

*TALMAGE, JAMES EDWARD, Ph. D., Professor of Geology, University of Utah, Salt Lake City, Utah. (50). 1906. **E**

Taltavall, Wm. Allen, M. D., Redlands, Cal. (57). **K**

*TANNER, PROF. JOHN HENRY, 7 Central St., Ithaca, N.Y. (47). 1899. **A B**

*Tarr, Ralph Stockman, Cornell University, Ithaca, N. Y. (49). 1901. **E**

Tasker, Arthur N., A. B., 107 Maryland Ave. N. E., Washington, D. C. (57). **C**

*Tatlock, John, President, Washington Life Ins. Co., 141 Broadway, New York, N. Y. (50). 1902. **A**

Taussig, James, Rialto Bldg., St. Louis, Mo. (50). **I**

Taverner, William, Ashland, Oregon. (56). **C**

Taylor, Albert Hoyt, Univ. of Wisconsin, Madison, Wis. (57). **B**

Taylor, Alexandrina, Hotel New Weston, 31 East 49th St., New York City. (57).

*Taylor, Alonzo Englebert, Professor of Pathology, University of California. Residence 1809 Broadway, San Francisco, Cal. (50). 1901. **C K**

Taylor, Charles E., 6 Wilbur Court, Cleveland, O. (54). **C**

*Taylor, Edson Homer, Teacher of Mathematics, Eastern Illinois State Normal School, Charleston, Ill. (53). 1906. **A**

Taylor, Edward B., Pittsburg, Pa. (50). **D**

*Taylor, Edward Randolph, Penn Yan, N. Y. (39). 1903. **C**

*Taylor, Edward Wyllys, M. D., Harvard Medical School, Boston, Mass. (50). 1902. **K**

Taylor, Estes Park, Grand Junction, Colo. (57). **F**

*Taylor, Frank B., 548 Home Ave., Fort Wayne, Ind. (39). 1897.

Taylor, Henry W., Chief Engineer, House of Representatives, 100 Fifth St. N.E., Washington, D. C. (52). **D**

Taylor, J. Erskine, M. D., Rockland, Pa. (51). **K**

Taylor, James, State Inspector of Mines, Peoria, Ill. (56). **D**

Taylor, James Landon, M. D., Wheelersburg, Ohio. (51). **K**

*Taylor, James M., Colgate University, Hamilton, N. Y. (33). 1901. **A D**

Taylor, Lewis H., M. D., 83 S. Franklin St., Wilkes-Barre, Pa. (51). K

Taylor, Robert S., Box 2019, Fort Wayne, Ind. (39).

Taylor, Wm. Alton, U. S. Department of Agriculture, Washington, D. C. (52). G

Tays, Eugene Aug. Hoffman, C. E., E. M., Consulting Mining Engineer, Fuerte, Sinaloa, Mexico. (50). D E

Teeters, Wilber John, State University of Iowa, Iowa City, Iowa. (50). C F K

Teeple, John Edgar, 164 Front St., New York City. (57). C

*Terry, B. T., M. D., Rockefeller Institute, Ave. A and 66th St., New York, N. Y. (54). 1907. K

*Terry, Robert James, 8 Strathmore Rd., Brookline, Mass. (53). 1906. K

*Tesla, Nikola, LL.D., 55 W. 27th St., New York, N. Y. (43). 1895. B

Thacher, John Leymour, M. D., 839 Madison Ave., New York City. (57). K

Thaw, Benjamin, Morewood Place, Pittsburg, Pa. (50). A D

Thaw, Mrs. William, Box 1086, Pittsburg, Pa. (41). H

*Thaxter, Roland, Ph. D., Professor of Cryptogamic Botany, Harvard University, Cambridge, Mass. (50). 1901. G

*Thayer, William S., M. D., 406 Cathedral St., Baltimore, Md. (52). 1903. K

Thelberg, Elizabeth B., M. D., Resident Physician and Professor of Physiology and Hygiene, Vassar College, Poughkeepsie, N. Y. (50). F K

Thiessen, Alfred Henry, Mount Weather, Bluemont, Va. (51). B

*Thom, Charles, Agric. Exper. Station, Storrs, Conn. (50). 1901. G

*Thomas, Benjamin F., Professor of Physics, State University, Columbus, Ohio. (29). 1882. A B

Thomas, Lancaster, 1932 Mt. Vernon St., Philadelphia, Pa. (52). B F

*Thomas, Prof. M. B., Wabash College, Crawfordsville, Ind. (41). 1894. G

Thomas, Paul K. M., 50 Morningside Ave. E., New York City. (57).

Thomasson, A. H., M. D., 140 Boylston St., Boston, Mass. (53). K

Thompson, Almon Harris, 1729 12th St. N.W., Washington, D. C. (52).

*Thompson, Alton Howard, 720 Kansas Ave., Topeka, Kan. (33). 1902. H

Thompson, Miss Anna F., P. O. Box 32, Summit, N. J. (49).

Thompson, Benj., Chief Engineer, T. & B. V. Ry. Co., Hillsboro, Texas. (52). D

THOMPSON, HENRY DALLAS, 11 Morven St., Princeton, N. J. (57). A

Thompson, Hugh L., Consulting Mechanical Engineer, Waterbury, Conn. (51). D

Thompson, James David, Library of Congress, Washington, D. C. (52). A B

Thompson, James E., 130 Howells Ave., Milwaukee, Wis. (48).

Thompson, James Edwin, 3224 Broadway, Galveston, Texas. (5c)

Thompson, J. L., M. D., 232 N. Illinois St., Indianapolis, Ind. (39). F

*Thompson, Joseph Osgood, Amherst College, Amherst, Mass. (41). 1893.

Thompson, Millett Taylor, Ph. D., Clark University, Worcester, Mass. (51). F

Thompson, Ralph Leroy, A. M., M. D., 1400 S. Grand Ave., St. Louis, Mo. (57).

Thompson, Robt. B., Biological Dept., Univ. of Toronto, Toronto, Canada. (57). F G

Thompson, Robert M., 43 Exchange Place, New York, N. Y. (49).

Thompson, Rev. Walter, D. D., Garrison-on-Hudson, N. Y. (49).

Thompson, William, Mining, Metallurgical and Mechanical Engineer, Rossland Great Western Mines, Ltd., Rossland, B. C. (50). D E

*Thompson, W. Gilman, M. D., 34 E. 31st St., New York, N. Y. (50). 1902. F K

*Thomson, Elihu, Swampscott, Mass. (37). 1888. B

*Thomson, Wm., M. D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. B

*Thornber, John J., Botanist, Agr. Exper. Station, Tucson, Arizona. (50). 1905. G

*Thornburg, Charles L., Lehigh Univ., S. Bethlehem, Pa. (44). 1897. A

*Thorndike, E. L., Ph. D., Adjunct Prof. of Genetic Psychology, Columbia Univ., New York, N. Y. (49). 1901. H I K

THORNE, MRS. PHOEBE ANNA, 558 Madison Ave., New York, N. Y. (50).

Thornton, William M., Professor of Applied Mathematics, University of Virginia, Charlottesville, Va. (53). A

Thorp, Frank H., 200 Mt. Veronn St., West Roxbury, Mass. (57).

*Thruston, Gates Phillips, Nashville, Tenn. (38). 1890. H

*Thruston, R. C. Ballard, Ballard & Ballard Co., Louisville, Ky. (36). 1896. E

Thurber, Charles Herbert, 29 Beacon St., Boston, Mass. (52). I
Thurber, Sam'l Wood, M. D., 104 East 39th St., New York City. (57). K
*Thwing, Charles Burton, Western Reserve Univ., Cleveland, Ohio. (54). 1906. B
Tibbals, Charles Austin, Jr., Instructor in Chemistry, Univ. of Wisconsin, Madison, Wis. (54). C
Tibbals, George Attwater, 148 Milton St., Brooklyn, N. Y. (51).
Tiffany, Chas. L., Fifth Ave. and 37th St., New York City. (57).
Tiffany, Lyman, 123 Pelham St., Newport, R. I. (52).
Tiffany, Louis C., 401 Fifth Ave., New York, N. Y. (50).
*Tight, William George, President University New Mexico, Albuquerque, N. M. (39). 1900. E
*Tilghman, B. C., 2210 St. James Place, Philadelphia, Pa. (54). 1906.
Tilley, Charles Edward, Teacher of Physics and Chemistry, Hope Street High School, Providence, R. I. (50). B C
*Tillman, Col. Samuel E., U. S. A., Prof. Chemistry, Mineralogy and Geology, West Point, N. Y. (54). 1906. B C E
Tilson, P. S., Associate Professor of Chemistry, A. and M. College, College Station, Tex. (50). C
*Tilton, Prof. John Littlefield, Simpson College, Indianola, Iowa. (50). 1906. E
Timolat, J. G., 24 Tompkins Ave., New Brighton, S. I., N.Y. (57).
*Tingle, Dr. J. Bishop, McMaster Univ., Toronto, Canada. (50). 1903. C
*Titchener, E. B., Professor of Psychology, Cornell University, Ithaca, N. Y. (51). 1902. H
*Tittmann, Otto H., Supt. U. S. C. and G. Survey, Washington, D. C. (24). 1888. A
Titus, E., Jr., 104 Washington St., Titusville, Pa. (50).
Titus, E. S. G., Agric. Exper. Station, Logan, Utah. (50). 1906. F
Toch, Maximilian, 261 W. 71st St., New York. (57). C
Todd, Albert M., Kalamazoo, Mich. (37). C
*Todd, Prof. David, Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. A B D
*Todd, Prof. James E., State Univ., Vermillion, S. Dak. (22). 1886. E F
Todd, J. H., M. D., Christmas Knoll, Wooster, Ohio. (48).
Todd, William J., M. D., Mt. Washington, Baltimore, Md. (51). K
Tompkins, Stonewall, M. E., Miller School, Va. (51). D
Tonnele, Theodore, Metallurgical Engineer, 919 College Ave., Pittsburg, Pa. (50). E
Toothe, William, Madison, N. J. (49).

*Torrey, Harry Beal, Ph. D., Asst. Prof. Zoology, University of California, Berkeley, Cal. (5?). 1905. F

Totman, David M., M. D., 303 Montgomery St., Syracuse, N. Y. (50). K

*Tower, Olin F., Ph. D., Assistant Professor of Chemistry, Adelbert College, Cleveland, Ohio. (50). 1903. C

*Tower, Ralph Winfred, Ph. D., Curator of Physiology, Am. Mus. Natural History, New York, N. Y. (53). 1905. K

Tower, William Lawrence, Zoology Bldg., Univ. of Chicago, Chicago, Ill. (55). F

*Towle, William Mason, Enosburg Falls, Vt. (44). 1902. D

*Townley, Sidney Dean, International Latitude Observatory, Ukiah, Cal. (53). 1906. A

*Townsend, Miss Anna B., 118 Lambert St., Philadelphia, Pa. (52). F G

*Townsend, Charles O., U. S. Dept. Agriculture, Washington, D. C. (46). 1902. G

*Townsend, Edgar Jerome, 501 John St., Champaign, Ill. (54). 1906. A

Townsend, John W., Room 1112 Arcade Building, Philadelphia, Pa. (54)

*Tracy, Samuel M., Biloxi, Miss. (27). 1881. G

Tracey, J. Irving, Pennington, N. J. (57). B

Transeau, E. N., Ph. D., Dept. Botany, State Normal School, Charleston, Ill. (53). G

*Traphagen, Frank W., Ph. D., Professor of Metallurgy, Colorado School of Mines, Golden, Colo. (35). 1899. C E F

Trask, Spencer, William St. corner Pine St., New York, N. Y. (50). I

Treadwell, Aaron L., Prof. of Biology, Vassar College, Poughkeepsie, N. Y. (57).

Treat, Erastus B., 942 St Nicholas Ave., New York, N. Y. (29) F I

*Trelease, Wm., Ph. D., Director Missouri Botanical Gardens, St. Louis, Mo. (39). 1891. G

Tremoulet, J. Sydney, Local Manager, Grasselli Chemical Co., P. O. Box 1108, New Orleans, La. (55). C

Trimble, Robert E., Asst. Meteorologist and Irrigation Engineer, Agricultural College, Fort Collins, Colo. (50). D E

Trotter, Dr. Spencer, Swarthmore College, Swarthmore, Penna. (55). E H

*Trowbridge, Augustus, Ph. D., Princeton Univ., Princeton, N. J. (47). 1900. B

*Trowbridge, Charles Christopher, Tutor in Physics, Columbia University, New York, N. Y. (50). 1901. B

True, A. C., Ph. D., Director, Office of Experiment Stations, U. S. Dept. Agriculture, Washington, D. C. (52).

*True, Fred. W., U. S. National Museum, Washington, D. C. (28). 882. F

*True, Rodney Howard, U. S. Dept. Agriculture, Washington, D. C. (46). 1899. G

Truesdell, George, Room 22, Wyatt Building, Washington, D. C. (49). I

Truman, James, D. D. S., Dept. of Dentistry, Univ. of Pennsylvania, 4505 Chester Ave., Philadelphia, Pa. (54).

Tucker, Miss Arabella H., Professor of Botany, State Normal School, Worcester, Mass. (54). G

Tucker, George M., Ph. D., Manager, Tucker Plant Breeding Farm, Blodgett, Mo. (53). C

Tucker, Colonel N. Beverley, Professor of Geology and Associate Professor of Chemistry, Virginia Military Institute, Lexington, Va. (55). C E

*Tucker, Richard Hawley, C. E., Astronomer, Lick Observatory, Mt. Hamilton, Cal. (50). 1902. A D

Tucker, William Albert, University Park, Colo. (51). G

Tucker, William Conquest, Civil and Sanitary Engineer, 156 Fifth Ave., New York, N. Y. (51). D

*Tucker, Willis G., M. D., Albany Medical College, Albany, N. Y. (29). 1888. C

*TUCKERMAN, ALFRED, Ph. D., 342 W. 57th St., New York, N. Y. (39). 1891. C

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Tuohy, John, Tulare, California. (50). B I

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Turnbull, Thomas, Jr., M. D., Asst. Professor of Practice of Medicine, Allegheny University, Allegheny, Pa. (50). F K

*Turneaure, Frederic Eugene, Professor of Bridge and Sanitary Engineering, University of Wisconsin, Madison, Wis. (51). 1906. D

*Turner, Arthur Bertram, Ph. D., College of City of New York, New York, N. Y. (52). 1906. A

Turrentine, J. W., 804 E. Seneca St, Ithaca, N. Y. (53). C

*Tuttle, Prof. Albert H., University of Virginia, Charlottesville, Va. (17). 1874. F

Tutton, Charles H., Asst. Engineer, Department of Public Works, City Hall, Buffalo, N. Y. (53). D

Tweedy, Miss Alice B., Spuyten Duyvil, New York, N. Y. (49).

*Twitchell, E., Wyoming, Ohio. (39). 1891. C

*Tyler, Ansel Augustus, Ph. D., Professor of Science, Bellevue College, Bellevue, Neb. (50). 1906.

Tyler, Chas. R., 402 W. 23d St., New York City. (57). C

Tyler, Frederick Jared, U. S. Dept. of Agriculture, Washington, D. C. (54). G

*Tyler, Dr. Harry W., 491 Boylston St., Boston, Mass. (51). 1906.

*Tyrrell, Joseph Burr, Mining Engineer, 87 Binscarth Rd., Toronto, Canada. (50). 1903. D E

*Udden, Johan August, 1000 38th St., Rock Island, Ill. (54). 1906. E

*Uhler, Dr. Philip R., 254 W. Hoffman St., Baltimore, Md. (19). 1874. E F

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Ullmann, Prof. H. M., Asst. Prof. Analytical and Industrial Chemistry, Lehigh University, So. Bethlehem, Pa. (54). C

Ulrey, Albert B., A. M., Prof. Biology, University of Southern California, Los Angeles, Cal. (54). F

*Underwood, Lucien M., Columbia University, New York, N. Y. (23). 1885. G

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*Ward, Henry L., Director, Public Museum, Milwaukee, Wis. (51). 1906. E
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Whitmore, F. E., Curator, Cortland Science Club, Cortland, N. Y. (54).

*Whitney, Miss Mary W., Vassar College Observatory, Poughkeepsie, N. Y. (47). 1900. A

Whitney, Solon Franklin, A. M., Public Library, Watertown, Mass. (52).

*Whitney, Willis Rodney, care General Electric Co., Schenectady, N. Y. (46). 1900. C

*Whittelsey, Theodore, Ph. D., Associate Professor of Chemistry, Northwestern University, Evanston, Ill. (53). 1906. C

Whittier, Frank Nathaniel, Bowdoin College, Brunswick, Me. (54). K

Wickham, Henry F., Prof. Entomology, State University, Iowa City, Iowa. (54). F

Wiechmann, F. G., Ph. D., P. O. Box 79, Sta. W., Brooklyn, N. Y. (50). F K

*Wiegand, Karl McKay, Ph. D., Cornell University, Ithaca, N. Y. (45). 1899. G

Wiggin, Frederick Holme, 55 W. 36th St., New York, N. Y. (57). K

Wight, William F., U. S. Dept. Agriculture, Washington, D. C. (54). C

Wightman, Merle J., Electrical Engineer, 302 Broadway, New York, N. Y. (50). D

Wilbour, Mrs. Charlotte B., 40 Central Park, South, New York. N. Y. (28).

*Wilbur, A. B., Middletown, N. Y. (23). 1874. E

Wilbur, M. T., 195 Broadway, New York, N. Y. (57).

*Wilbur, Ray Lyman, M. D., Assistant Professor of Physiology, Stanford University, Cal. (50). 1901. F K

Wilcox, Mrs. Aaron Morley, The Arlington, Washington, D. C. (52).

*Wilcox, Edwin Mead, Ph. D., Prof. of Botany, Ala. Polytechnic Institute, Auburn, Ala. (50). 1901. F G

Wilcox, Miss Emily T., Middletown, Conn. (33). A B

Wilcox, Franklin A., care of Wilcox & Grun, 1 Broadway, New York, N.Y. (57).

Wilcox, Guy Maurice, Professor of Physics, Armour Institute, Chicago, Ill. (53). B

Wilcox, Wendell Garrett, Professor of Chemistry, Alfred University, Alfred, N. Y. (56). C

*Wilder, Burt Green, Prof. of Neurology, Cornell University, Ithaca, N. Y. (51). 1902. F

*Wilder, Harris Hawthorne, Ph. D., Professor of Zoology, Smith College, Northampton, Mass. (52). 1905. F

Wiley, Andrew J., Consulting Engineer, Boise, Idaho. (51). D

*Wiley, Harvey W., Ph. D., U. S. Dept. Agriculture, Washington, D. C. (21). 1874. C

*Wiley, William H., C. E., 43 E. 19th St., New York, N. Y. (50) 1906. DE

Wildman, Edward E., 214 St. Marks Sq., Phila., Pa. (57).

Wilkins, Miss Lewanna, Eastern High School, Washington, D.C. (52). FG

*Wilkinson, Levi Washington, Professor of Industrial and Sugar Chemistry, Tulane University, New Orleans, La. (50). 1903.

*Willard, Julius Terrass, Dir. Kans. State Exper. Sta., Manhattan, Kans. (50). 1906. C

*Willcox, Miss Mary Alice, Ph. D., Professor of Zoology, Wellesley College, Wellesley, Mass. (50). 1901. F

Willcox, David, 20 Liberty St., New York, N. Y. (57).

*Willcox, Walter F., Ph. D., Professor of Economics, Cornell University, Ithaca, N. Y. (50). 1901. I

Wille, Henry Valentin, M. E., Engineer of Tests, Baldwin Locomotive Works, 500 N. Broad St., Philadelphia, Pa. (51). D

Willett, James R., 434 W. Jackson Blvd., Chicago, Ill. (53). D

Williams, Anna Wessels, M. D., 416 West 118th St., New York, N. Y. (56). K

*Williams, Benezette, 153 La Salle St., Chicago, Ill. (33). 1887. D

Williams, Charles B., North Carolina Dept. of Agric., Raleigh, N. C. (47).

*Williams, Charles H., M. D., 1069 Boylston St., Boston, Mass. (22). 1874.

Williams, Charles M., M. D., 48 East 49th St., New York, N. Y. (57). K

Williams, Mrs. Chauncey P., 284 State St., Albany, N. Y. (52).

*Williams, Clarke Benedict, Prof. of Mathematics, Kalamazoo College, Kalamazoo, Mich. (54). 1906. A

*Williams, Prof. Edw. H., Jr., Andover, Mass. (25). 1894. DE

*Williams, Francis H., M. D., 505 Beacon St., Boston, Mass. (29). 1890.

Williams, Frank Blair, Ph. D., Assistant Professor Civil Engineering, Union College, Schenectady, N. Y. (53). D

Williams, Frank H., Greene, N. Y. (50). D

*Williams, Prof. Henry Shaler, Cornell University, Ithaca, N. Y. (18). 1882. EF

*Williams, Herbert U., M. D., Prof. of Pathology and Bacteriology, University of Buffalo, Buffalo, N. Y. (54). 1906. K

Willams, Ira Abraham, Iowa State College, Ames, Iowa. (52). **D E**
Williams, J. C., 221 Orchard St., Ridgeway, Pa. (51). **E**
Williams, John T., 27 William St., New York, N. Y. (57). **C D**
*Williams, Dr. J. Whitridge, Professor of Obstetrics, Johns Hopkins University, Baltimore, Md. (50). 1901. **F K**
*Williams, Leonard Worcester, 89 Brown St., Providence, R.I. (52). 1906. **F**
Williams, Mabel Clare, Ph. D., State Univ. of Iowa, Iowa City, Iowa. (52). **H**
*Williams, Stephen Riggs, Professor of Biology, Miami University, Oxford, Ohio. (50). 1906. **F**
*Williamson, Edward Bruce, Bluffton, Ind. (50). 1906. **F**
Williamson, Homer D., M. D., Bank St., Lorain, Ohio. (51). **K**
Williamson, Mrs. M. Burton, 136 Magnolia Ave., Hollywood, Cal. (44). **F**
*Willis, Bailey, U. S. Geological Survey, Washington, D.C. (36). 1890. **E**
*Williston, Arthur L., Director Dept. Science and Technology, Pratt Institute, Brooklyn, N. Y. (51). 1906. **D**
*Williston, Dr. Samuel W., University of Chicago, Chicago, Ill. (51). 1902. **F K**
*Willoughby, Charles C., Peabody Museum, Cambridge, Mass. (45). 1897. **H**
*Wills, Dr. Albert P., Instructor in Mechanics, Columbia University, New York, N. Y. (53). 1906. **A B**
Wills, J. Lainson, F. C. S., Analytical and Technical Chemist, 133 Midwood St., Brooklyn, N. Y. (50). **B F C**
WILMARTH, MRS. HENRY D., West Boxford, Mass. (40).
Wilmore, John J., Professor of Mechanical Engineering, Ala. Polytechnic Institute, Auburn, Ala. (51). **D**
Wilson, Miss Alisan, The Farragut, Washington, D. C. (52). **H**
*Wilson, Charles Branch, State Normal School, Westfield, Mass. (52). 1906. **F**
*Wilson, Delonza Tate, Assistant Professor of Mathematics and Astronomy, Case School of Applied Science, Cleveland. Ohio. (53). 1906. **A**
*Wilson, E. B., Columbia University, New York, N. Y. (49). 1900.
Wilson, Francis D., Prof. of Chemistry, Virginia Polythenic Inst., Blacksburg, Va. (57). **C**
Wilson, Fredk. Morse, M. D., 834 Myrtle Ave., Bridgeport, Conn. (51). **K**
WILSON, J. HOWARD, Castine, Maine. (57). **E H**
*Wilson, Henry Van Peters, Professor of Biology, University of North Carolina, Chapel Hill, N. C. (50). 1901. **F**

Wilson, John C., Cosmus Club, Washington, D. C. (49). I

Wilson, Prof. Margaret B., 72 East 77th St., New York, N. Y. (57).

Wilson, Norman Richard, Lecturer in Mathematics, Wesley College, Winnipeg, Manitoba, Canada. (55). 1907. A

Wilson, Robert N., Macleod, Alberta, Canada. (42). H

*Wilson, William Powell, Director Philadelphia Museums, 34th and South St., Philadelphia, Pa. (38). 1889. G

Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. A D

Willson, Mortimer, M. D., M. D., 6th & Water Sts., Port Huron, Mich. (50). A F

*Willson, Robert W., 64 Brattle St., Cambridge, Mass. (30). 1890. A B

Wimpfheimer, Chas. A., 131–137 Spring St., New York N. Y. (57).

*Winchell, Alexander Newton, Professor of Geology and Mineralogy, State School of Mines, Butte, Mont. (50). 1903. E

*Winchell, Horace V., Room 220, Grand Northern Railway Bldg., St. Paul, Minn. (34). 1890. C E

*Winchell, Prof. N. H., 113 State St., Minneapolis, Minn. (19). 1874. E H

Windesheim, Gustave, M. D., 255 Main St., Kenosha, Wis. (51). K

Windsor, Sarah Sweet, M. D., 657 Boylston St., Boston, Mass. (47). F H

Winfield, James MacFarland, M. D., 47 Halsey St., Brooklyn, N. Y. (57).

Wing, Henry H., Professor of Animal Husbandry, Cornell University, Ithaca, N. Y. (56). F

*Winslow, Charles Edward Amory, Asst. Prof. Biology, Mass. Inst. Tech., Boston, Mass. (51). 1903. F K

Winslow, Mrs. C. E. A., care of Miss M. D. Hale, Chestnut Hill Ave., Brookline, Mass. (52). F

Winston, Isaac, The Portner, Washington, D. C. (55).

Winter, Mahlon A., 339 Penna. Ave., Washington, D. C. (52). D E I K

Winterhalter, A. G., Commander, U. S. N., U. S. S. Paducah, care Postmaster, Portsmouth, N. H. (37). 1893. A

Wiseman, Carl Marshall, Optician, 301 W. Chestnut St., Louisville, Ky. (53).

*Wissler, Clark, Ph. D., Am. Mus. Nat. Hist., 77th St. and 8th Ave., New York, N. Y. (54). 1906. F

*Withers, W. A., Professor of Chemistry, North Carolina College of Agriculture and Mechanic Arts, West Raleigh, N. C. (33). 1891. C

Witherspoon, Thomas A., Patent Office, Dept. of Interior, Washington, D. C. (52). C

*Witmer, Lightner, Ph. D., Asst. Prof. Psychology, Univ. of Pennsylvania, Philadelphia, Pa. (46). 1905. H

Witte, Max Ernest, M. D., Superintendent of Clarinda State Hospital, Clarinda, Ia. (51). K

*Witthaus, Dr. R. A., 55 W. 33d St., New York, N. Y. (35). 1890.

Woefel, Albert, M. D., Assistant in Physiology, University of Chicago, Chicago, Ill. (54). K

Woglum, R. S., N. C. Dept. Agriculture, Raleigh, N. C. (54). F

Wolcott, Edson Roy, Prof. of Physics, Colorado School of Mines, Golden, Colo. (54). 1907. B

Wolf, Ernest, 73–77 9th St., Long Island City, N. Y. (57). C

Wolfe, Elmer Ellsworth, Ph. D., Principal of the Academy, Marietta College, Marietta, Ohio. (51). B C G

Wölfel, Paul L., 362 Green Lane, Roxborough, Philadelphia, Pa. (51). D

*Wolff, Frank A., Ph. D., Bureau of Standards, Washington, D. C. (47). 1900. B

Wolff, Henry Albert. M. D., 501 West 138th St., New York, N. Y. (57). K

*Wolff, Dr. John E., University Museum, Cambridge, Mass. (36). 1894. E

*Woll, Fritz Wilhelm, 424 Charter St., Madison, Wis. (42). 1897. C

Wolverton, Byron C., Engineer, N. Y. & Pa. Telephone and Telegraph Co., 321-323 Montgomery St., Syracuse, N. Y. (50). D

*Wood, Arthur J., State College, Pa. (51). 1905. D

Wood, Casey A., D. C. L., M. D., Pres. Am. Acad. Med., 72 Madison St., Chicago, Ill. (56). F K

Wood, Mrs. Cynthia A., 117 W. 58th St., New York, N. Y. (43).

Wood, Miss Elvira, 1435 Euclid St., Washington, D. C. (47).

Wood, Francis Carter, 201 West 55th St., New York, N. Y. (57). K

Wood, Henry A. Wise, 1 Madison Ave., New York, N. Y. (57).

Wood, James, Mount Kisco, New York, N. Y. (57).

*Wood, Stuart, 400 Chestnut St., Philadelphia, Pa. (51). 1906.

*Wood, Thomas D., M. D., Prof. of Physical Education, Teachers' College, Columbia University, New York, N. Y. (51). 1902. K

Wood, Walter, 400 Chestnut St., Philadelphia, Pa. (33). F I.

Woodbridge, Frederick J. E., Professor of Philosophy, Columbia University, New York, N. Y. (52). 1905. H

Woodbridge, S. Homer, Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology, Boston, Mass. (56). D

*Woodbury, C. J. H., Amer. Telephone and Telegraph Co., 125 Milk St., Boston, Mass. (29). 1884. D

Woodbury, Frank, M. D., 218 South 16th St., Philadelphia, Pa. (52). K

Woodhull, Brig.-Gen. Alfred A., U. S. A., Retired, 46 Bayard Lane, Princeton, N. J. (51). K

*Woodhull, John Francis, Teachers' College, Morningside Heights, New York, N. Y. (43). 1899.

Woodhull, Gen. Maxwell Van Zandt, U. S. A., 2033 G St., N.W., Washington, D: C. (52).

Woodhull, Marianna, 151 West 76th St., New York, N. Y. (57).

Woodman, Joseph Edmund, A. M., S. D., Professor of Geology and Mineralogy, Dalhousie University, Halifax, N. S. (56). E

Woodruff, Major Charles Edward, Surgeon, U. S. A., Plattsburgh, N. Y. (54). H I K

Woodruff, Lorande Loss, Instructor in Biology, Williams College, Williamstown, Mass. (52). F

*Woods, Albert F., U. S. Dept. Agric., Washington, D. C. (43). 1897. G

*Woods, Charles D., Professor of Agriculture, University of Maine, Orono, Maine. (50). 1901. G

*Woods, Frederick Adams, M. D., 1006 Beacon St., Brookline, Mass. (51). 1902. K

Woodward, Augustus J., Mt. Auburn, Cincinnati, Ohio. (57). E

*Woodward, Prof. Calvin M., Washington University, St. Louis, Mo. (32). 1884. A D I

*Woodward, R. S., President, Carnegie Institution, Washington, D.C. (33). 1885. A B D

*Woodward, Samuel B., M. D., 58 Pearl St., Worcester, Mass. (51). 1906. K

Woodward, Sherman, M. A. B., M. S., Office of Experiment Stations, Dept. Agriculture, Washington, D. C. (57). A

Woodward, William Carpenter, E. E., 5 Charles Field St., Providence, R. I. (50). C D

*Woodworth, C. W., Asst. Professor of Entomology, University of California, Berkeley, Cal. (50). 1906. F

Woodworth, George Kean, Councillor-at-Law, 31 State St., Boston, Mass. (50). D

*Woodworth, Jay Backus, Assistant Professor of Geology, Harvard University, Cambridge, Mass. (54). 1906. E

Woodworth, R. S., Ph. D., Columbia University, New York, N. Y. (49). 1901. H K

Woodworth, William McMichael, Ph. D., 149 Brattle St., Cambridge, Mass. (44). 1898. F

Wollen, William Watson, 518 Am. Central Life Bldg., Indianapolis, Ind. (55). **F**

Woolley, Paul G., U. D., Chief Medical Inspector and Medical Advisor, His Siamese Majesty's Gov., Bangkok, Siam. (55). **C**

Wooster, Lyman Child, Ph. D., Prof. Biology and Geology, State Normal School, Emporia, Kans. (54). **E F**

Wooton, Elmer O., Professor of Botany, New Mexico Agricultural College, Agricultural College, N. M. (56). **G**

*Worcester, Dean C., U. S. Philippine Commission, Manila, P. I. (46). 1903. **F H**

Worcester, Wilfred J., 342 Lexington Ave., New York, N. Y. (57).

Work, Wm. R., Carnegie Technical Schools, Pittsburg, Pa. (57). **D**

Wren, Christopher, Plymouth, Pa. (54). **H**

Wright, Albert Hazens, Teacher of Zoölogy, 325 Dryden Road, Ithaca, N. Y. (56). **F**

Wright, Prof. Arthur W., Yale University, New Haven, Conn. (14). 1874. **A B**

*Wright, Carroll D., LL. D., President, Clark College, Worcester, Mass. (41). 1894. **I**

*Wright, Fred. Eugene, Ph D., U. S. Geological Survey, Washington, D. C. (52). 1906. **E**

*Wright, Prof. Geo. Frederick, Drawer C, Oberlin, Ohio. (29). 1882. **E H**

Wright, Jasper Heman, Teacher of Biology, Avon, N. Y. (56). **F G**

Wright, John S., Eli Lily & So., Indianapolis, Ind. (42). 1899. **G**

Wright, Jonathan, M. D., 44 W. 49th St., New York, N. Y. (43). **K**

*Wright, Walter C., 45 Milk St.. Boston, Mass. (54). 1906. **A**

*Wright, Walter Livingston, Jr., Professor of Mathematics, Lincoln University, Pa. (50). 1906. **A**

*Wrinch, Frank Sidney, Ph. D., Instructor in Experimental Psychology, Univ. of California, Berkeley, Cal. (52). 1906. **E K**

Wuensch, Alfred F., 1220 Corona St., Denver, Colo. (50). **C D**

WUNDERLICH, FREDERICK W., M. D., 165 Remsen St., Brooklyn, N. Y. (45).

Würtele, John Hunter, 1807 Pacific Ave., Spokane, Wash. (48).

*Würtele, Rev. Louis C., Acton Vale, P. Q., Canada. (11). 1875. **E**

*Wurts, Alexander Jay, Prof. of Applied Electricity, Carnegie Technical Schools, Carnegie Institute, Pittsburg, Pa. (50). 1906. **D**

Wyant, Alex. L., 141 West 85th St., New York, N. Y. (57).

Wyatt, Francis, 20 Fifth Ave., New York, N. Y. (57). **C**

*Wylie, Robert Bradford, Asst. Prof. Botany, State Univ. of Iowa, Iowa City, Iowa. (53). 1905. **G**

*Wyman, Walter, M. D., Surgeon-General, Public Health and Marine Hospital Service, Washington, D. C. (51). 1903. K

Yamanouchi, Shigeo, Hull Botanical Laboratory, Univ. of Chicago, Chicago, Ill. (57).

Yandell, Chas. R., 14 West 45th St., New York. N. Y. (57).

*Yanney, Benjamin F., Prof. Mathematics and Astronomy, Mt. Union College, Alliance, Ohio. (51). 1906. A

*Yarrow, Dr. H. C., 814 17th St. N.W., Washington, D. C. (23). 1874.

Yates, J. A., State Manual Training School, Pittsburg, Pa. (50). B C G

Yates, Lorenzo Gordin, Ph. D., President, Soc. Nat. History, Santa Barbara, Cal. (54). E F G H

Yatsu, Naohidé, Zoological Institute, Imperial University, Tokyo, Japan. (56). F

*Yerkes, Robert Mearns, Instructor in Comparative Psychology, Harvard University, Cambridge, Mass. (52). 1905. K

Yothers, W. W., U. S. Dept. of Agriculture, Washington, D. C (55). F

Youmans, Vincent J., 175 Elm Place, Mt. Vernon, New York. (43).

*Young, Miss Anne Sewell, Mt. Holyoke College, So. Hadley, Mass.

Young, A. V. E., Northwestern University, Evanston, Ill. (33). 1886. B C

*Young, C. A., Hanover, N. H. (18). 1874. A B D

Young, Geo. Albert, 163 Laurier Ave. West, Ottawa, Ont. (57). E

Young, Hugh Hampton, M. D., 1005 N. Charles St., Baltimore, Md. (53).

Young, Richard, 87 Lincoln Road, Brooklyn, N. Y. (57).

*Young, Stewart Woodford, Asst. Professor of Chemistry, Stanford University, Cal. (50). 1901. C

Young, Walter Douglas, E. E., B. & O. R.R. Co., 309 Oakdale Road, Roland Park, Baltimore, Md. (51). D

Zahm, George, Assistant Professor of Law, Yale University, New Haven, Conn. (53). I

*Zalinski, E. L., U. S. A., 201 East 16th St., New York, N. Y (36). 1891. D

Zeigler, J. L , M. D., Mount Joy, Pa. (52). C G K

Zeleny, Anthony, Assistant Professor of Physics, University of Minnesota, Minneapolis, Minn. (56). B

*Zeleny, Charles, Indiana University, Bloomington, Ind. (53). 1905 F

*Zeleny, John, Associate Professor of Physics, University of Minnesota, Minneapolis, Minn. (50). 1901. B

*Ziwet, Alexander, 644 S. Ingalls St., Ann Arbor, Mich. (38). 1890 A

Zuber, Wm. H., Jeanette, Pa. (52). B C

## INCORPORATED SCIENTIFIC BODIES.

[Holding membership under the provisions of Article 3 of the Constitution.]

Arizona, The University of, Library, Tucson, Arizona. (54).
Cincinnati, Public Library of, Cincinnati, Ohio. (53).
Iowa State University Library, Iowa City, Iowa. (54).
Jersey City Free Public Library, Jersey City, N. J. (52).
Manchester Institute of Arts and Sciences, Manchester, N. H. (48).
Marietta College Library, Marietta, Ohio. (51).
Michigan State Normal College, Ypsilanti, Michigan. (53).
Mt. Carmel Scientific Society, Mt. Carmel, Ill. (50).
Nebraska, The University of, Library, Lincoln, Neb. (51).
N. P. Coburn Library, Colorado College, Colorado Springs, Colo. (53).
Ohio State University Library, Columbus, Ohio. (54).
Philadelphia, The Free Library of, 1217-1221 Chestnut St., Philadelphia, Pa. (51).
P. M. Musser Public Library, Muscatine, Iowa. (51).
Pratt Institute Free Library, Ryerson St., Brooklyn, N. Y. (52).
St. Olaf Library, Northfield, Minn. (52).
Western Illinois State Normal School, Macomb, Ill. (55).
Wilmington Institute Free Library, Wilmington, Del. (52).

SUMMARY:

Corrected to December 1, 1907.

Surviving Founders, 2; Patrons, 4; Honorary Fellows, 3; Fellows, 1,862; Members, 3,193; Total, 5,058.

NOTE.—The omission of an address in the foregoing list indicates that letters mailed to that last printed were returned as uncalled for. Information of the present address of the members indicated is requested by the PERMANENT SECRETARY.]

## DECEASED MEMBERS.

[A list of deceased members of the Association, so far as known at the time of publishing the volume of Proceedings of the Springfield meeting, May, 1896, is given in that volume. At the Buffalo meeting the Council directed the Permanent Secretary to omit the printing of the full list of deceased members in the annual volumes and to print only the additions to the list. Since the publication of the list printed in the New Orleans Proceedings (Vol. 55), notices have been received of the decease of the following members.]

Almond, Thomas R., Station A, Yonkers, N. Y. (51). Died March 31, 1906.

Atkinson, Edward, 31 Milk St., Boston, Mass. (29).

Beckwith, Paul Edmond, U. S. National Museum, Washington, D. C. Died June 27, 1907.

Benjamin, Raphael, Hotel St. George, Brooklyn, N. Y. (34).

Benson, Frank Sherman, Long Island Historical Socety, Pierrepont St., Brooklyn, N. Y. (49). Died February, 1907.

BISHOP, HEBER R., Mills Building, New York, N. Y. (36).

Bogert, Stephen G., 39 West 75th St., New York, N. Y. Died February, 1907.

Bogue, E. E., Argicultural College, Mich.

Brock, Robert C. H., 1612 Walnut St., Philadelphia, Pa. (54).

Brodie, Paul Thomas, Clemson College, S. C. (50). Died November 3, 1907.

Brown, W. L., 42 West 72d St., New York, N. Y. (50). Died December 13, 1906.

Bryan, Walter, 139 East 21st St., New York, N. Y. (52).

Bull Storm, University of Wisconsin, Madison, Wis. (44). Died November 19, 1907.

Cabot, Samuel, 70 Kilby St., Boston, Mass. (50). Died November 26, 1906.

Caldwell, George C., Cornell University, Ithaca, N. Y. (23). Died September 5, 1907.

Carroll, James, 1224 U St. N. W., Washington, D. C. (50).

CILLY, FRANK H., Massachusetts Institute of Technology, Boston, Mass. (49). Died October, 1905.

Clark, Alex. S., Westfield, N. J. (33). Died November 30, 1906.

Clark, Gaylord Parsons, Syracuse University, Syracuse, N. Y. (50). Died September 1, 1907.

Coit, Joseph Howland, St. Paul's School, Concord, N. H. (50).

Cox, A. Beekman, Cherry Valley, N. Y. (50). Died February, 1906.

Cummings, Miss Clara E., Wellesley College, Wellesley, Mass. (47).

DOUGHTY, JOHN W., 165 Johnston St., Newburgh, N. Y. (19). Died December 12, 1905.

Evans, Thomas, University of Cincinnati, Cincinnati, Oiho. (53)

Gold, Theodore S., West Cornwall, Conn. (4). Died March, 1906.
Harriman, George B., 59 Lawrence Ave., Roxbury, Mass. (52). Died May, 1905.
Hasie, Montague S., Texas Bridge Co., Dallas, Texas. (51).
Haywood, John, Otterbein University, Westerville, Ohio. (30). Died December 12, 1906.
Heilprin, Angelo, Academy of Natural Sciences, Philadelphia, Pa. (52).
Hodgson, Richard, 15 Charles St., Boston, Mass. (54). Died December 20, 1905.
Jefferies, Wm. W., 474 Central Park, West, New York, N. Y. (33). Died February 23, 1906.
Jenkins, J. F., 48 Chicago St., Tecumseh, Mich. (51). Died October, 1906.
King, Theo. Ingalls, U. S. Naval Observatory, Washington, D. C. (52).
Kuntze, Otto, Villa Girola, San Remo, Italy. (49). Died January 28, 1907.
Latimer, Thomas S., 211 W. Monument St., Baltimore, Md. (50).
Lehmann, G. W., City Hall Annex, Baltimore, Md. (30). Died August 5, 1906.
Livermore, Mrs. M. A. C., care of F. P. Fish, Prescott St., Longwood, Mass. (29). Died November 12, 1906.
Lloyd, Andrew J., 315 Washington St., Boston, Mass. (47).
Logan, Walter S., 27 William St., New York, N. Y. (36).
Lufkin, Albert, Newton, Iowa. (31). Died June 27, 1907.
MacFarland, W. W., 22 William St., New York, N. Y. (49). Died October 30, 1905.
McQueeney, Francis J., 46 Dartmouth St., Boston, Mass. (51). Died October 1, 1907.
Magee, Louis J., 25 Broad St., New York, N. Y. (50). Died July, 1907.
Merrick, J. Vaughan, Roxborough, Philadelphia, Pa. (54). Died March 28, 1906.
Michelsen, Henry, Denver, Colo.
Miller, Edmund H., Columbia University, New York, N. Y. (50). Died November 8, 1906.
Miller, John A., 2500 Park Ave., Cairo, Ill. (22). Died January 7, 1904.
Mitchell, Roland G., 17 Battery Place, New York, N. Y. (50). Died June 7, 1906.
Mohr, Charles, Lawnton Ave., Oak Lane, Philadelphia, Pa. (51). Died October 31, 1907.
Newell, William Wells, Journal American Folk Lore, Cambridge, Mass. (41). Died January 19, 1907.

Patton, John, 925 Michigan Trust Co. Bldg., Grand Rapids, Mich. (50). Died May, 1907.

Paulmier, Frederick Clark, New York State Museum, Albany, N. Y. (47). Died March, 1906.

Penfield, S. L., Yale University, New Haven, Conn. (51). Died August, 1906.

Pettee, J. T., Meriden, Conn. (39).

Potts, Howard Newcomb, 466 N. 7th St., Philadelphia, Pa. (54). Died July, 1906.

PRUYN, JOHN V. L., Jr., Albany, N. Y. (29).

Quarles, James A., Washington and Lee University, Lexington, Va. (55). Died April 14, 1907.

Reese, Jacob, Box 554, Datona, Fla. (33). Died March 25, 1907.

Russell, Israel C., University of Michigan, Ann Arbor, Mich. (25).

Sayre, Robert H., South Bethlehem, Pa. (28). Died January, 1907.

SCHAFFER, Mrs. MARY TOWNSEND SHARPLESS, 1309 Arch St., Philadelphia, Pa. (38).

Sheldon, Walter L., 4533 Westminster Place, St. Louis, Mo. (54).

SCHERMERHORN, WM. C., 49 West 23d St., New York, N. Y. (36).

Schuyler, Philip, Irvington-on-Hudson, N. Y. (49).

Serrell, Edward Wellman, Forest Ave., West New Brighton, N. Y. (50). Died April 24, 1906.

Siemon, Rudolf, 22 E. Jefferson St., Fort Wayne, Ind. (40). Died August 26, 1907.

Simpson, Charles Baird, Department of Agriculture, Pretoria, Transvaal, South Africa. (52).

Steiner, Roland, Grovetown, Ga. (48).

Tanner, Zera Luther, 2204 R St. N. W., Washington, D. C. (52).

Ward, Henry A., 620 Division St., Chicago, Ill. (13). Died July 4, 1906.

Warder, Robert B., Howard University, Washington, D. C. (19).

WARINGTON, ROBERT, Rothamsted, Harpenden, England. (40). Died March 20, 1907.

Watters, William, 26 S. Common St., Lynn, Mass. (40). Died 1903.

Williams, Jacob Lafayette, 4 Walnut St., Boston, Mass. (51). Died May 15, 1906.

Wilson, William Hyatt, University of Wooster, Wooster, Ohio, (50). Died June 24, 1907.

Woodman, Durand, 127 Pearl St., New York, N. Y. (41). Died September, 1907.

Woods, John A., 120 Broadway, New York, N. Y. (49). Died March 17, 1907.

Yale, Leroy Milton, 432 Madison Ave., New York, N. Y. (54). Died September, 1906.

# THE FIFTY-SIXTH MEETING

## ITHACA, N. Y.

JUNE 28 to JULY 3, 1906

## SPECIAL SUMMER MEETING

SECTION A.

# Mathematics and Astronomy.

## OFFICERS OF SECTION A.

*Vice-President and Chairman of the Section.*

EDWARD KASNER, New York.

*Secretary.*

L. G. WELD, State University of Iowa, Iowa City, Iowa.

*Member of Council.*

C. S. HOWE.

*Sectional Committee.*

W. S. EICHELBERGER, Vice-President, 1906; EDWARD KASNER, Vice-President, 1907; L. G. WELD, Secretary, 1904–1908.
J. R. EASTMAN, 1 year; ORMOND STONE, 2 years; E. B. FROST, 3 years; E. O. LOVETT, 4 years; HARRIS HANCOCK, 5 years.

*Member of General Committee.*

GEORGE BRUCE HALSTED.

*Press Secretary.*

L. G. WELD.

[No meeting of Section A was held and no papers presented before this section at the Ithaca meeting.]

SECTION B.

# PHYSICS.

## OFFICERS OF SECTION B.

*Vice-President and Chairman of the Section.*

W. C. SABINE, Cambridge, Mass.

*Secretary.*

DAYTON C. MILLER, Cleveland, Ohio.

*Member of Council.*

*Sectional Committee.*

HENRY CREW, Vice-President, 1906; W. C. SABINE, Vice-President, 1907; D. C. MILLER, Secretary, 1904–1908.
A. G. WEBSTER, 1 year; GORDON F. HULL, 2 years; F. E. NIPHER, 3 years; E. L. NICHOLS, 4 years; A. TROWBRIDGE, 5 years.

*Member of General Committee.*

H. T EDDY.

*Press Secretary.*

J. R. BENTON.

# REPORT OF THE SECRETARY OF SECTION B.

At the summer meeting of the American Association for the Advancement of Science, held in Ithaca, N. Y., from June 28 to July 3, 1906, Section B met in joint sessions with the American Physical Society. The section was, in an especial sense, the guest of the department of physics of Cornell University, for on this occasion there occurred the formal dedication of the new Rockefeller Hall of Physics. At the dedication exercises there were addresses by President Schurman, Professor E. L. Nichols, Dr. Elihu Thomson, Professor W. H. Welch and by Professor W. A. Anthony (read by Professor Merritt, in Professor Anthony's absence). After the addresses, the magnificent laboratory was opened for inspection.

On account of the interest in the new laboratory, no doubt, the attendance at the regular sessions was large, there being about seventy present. The president of the American Physical Society being absent, the vice-president of Section B, Professor W. C. Sabine, presided at all the sessions. A very interesting joint program of twenty-seven papers was presented. Abstracts and titles are given below. Besides the features already mentioned, several receptions and excursions, and the general hospitality of Cornell University added greatly to the enjoyment of the meetings. This summer meeting was very successful.

*A New Type of Young's Modulus and Hooke's Law Apparatus:* B. B. BRACKETT, Clarkson School of Technology.

This apparatus has a horizontal bed or base of wood, about 1.8 m. long, 20 cm. wide and 5 cm. thick. At one end is a clamp elevated 6 cm. to hold the wire tested, and at the other end is a rather large disk pulley over which the wire is drawn, while weights attached to the vertical portion of the wire beyond the pulley supply the desired tensions.

To compensate for the springing of the light and not very rigid base, an easily rolling platform is placed upon the base, between it and the wire. One end of this platform is held by a spring in firm contact with the clamp just at the point where it grips the wire, but the platform is entirely free from the wire at all other points.

A micrometer microscope is placed on the end of the platform next to the pulley to read the elongations of the wire. This arrangement keeps the microscope at the same distance from the fixed end of the wire, however much the plank base may be warped or shortened by the tensions placed on the wire.

The apparatus is of very simple construction, is easily used, quickly adjusted, and gives results of the most satisfactory kind.

*A Convenient Lecture Room Resistance for Electrical Experiments:* B. B. BRACKETT, Clarkson School of Technology.

The resistance is to be used for controlling the current from a dynamo circuit. Usually a tap is made from the lighting mains.

Twelve incandescent lamps are arranged within a partially open box, 70 cm. long and 25 cm. square. Single pole, double throw switches are connected to the lamps so that all possible parallel series and combination groupings are readily obtained.

While open enough for ventilation and to make the switches easily accessible, the containing box protects both lamps and switches from all the usual accidents to such apparatus, and enables one to use it in any place or position, on either end or on any side.

All the connecting wires are plainly visible and this, with the regular arrangement of the switches, shows at a glance what grouping of the lamps is being used. Hence there is little probability of making a mistake. Short circuits cannot be made by any position of the switches.

*Two Neglected Factors in the Determination of Musical Quality:* W. C. SABINE, Harvard University.

The musical quality of a sound in an ordinary room or other confined space is very greatly affected by the character of the walls. Diagrams are presented showing the effects of various wall surfaces and substances. The other factor is the sensitiveness of the ear to sounds of different pitch and a diagram is presented showing the relative intensity for equal loudness under ordinary musical conditions.

*Silver Perchlorate as the Electrolyte for the Silver Coulometer:* HENRY S. CARHART, H. H. WILLARD and W. D. HENDERSON, University of Michigan.

*A New Alternating-current Galvanometer:* L. A. FREUDENBERGER, Lehigh University.

*A Lecture Experiment in Electrolytic Thermo-Electromotive Force:* HENRY S. CARHART, University of Michigan.

*Note on the Graphical Representation of Non-Sinusoidal Alternating Currents:* FREDERICK BEDELL, Cornell University.

*Spark Potentials in Liquid Dielectrics:* ROBERT F. EARHART, Ohio State University.

Measurements on the potential required to cause a spark to pass between a ball and plate were made, with kerosene, olive oil, paraffin oil, and a transformer oil as the intervening dielectrics.

Distances of separation vary from .003 to .118 mm. and were measured in terms of wave-lengths of sodium light. A plane surface was attached to the movable carriage of an interferometer. This was brought in contact with a ball mounted on the interferometer base. These were separated and the fringes crossing the interferometer field noted. From this data distances of separation of the surfaces were computed. P.D.'s were obtained from an A.C. transformer and were measured with a Weston voltmeter. The data secured are compared with similar measurements made by the author when air was used as a dielectric. Spark potential-distance curves for the various oils used give curves similar in form to those for air.

These experiments on the limited number of oils used indicate: 1. A higher potential gradient for small than for large distances. 2. That for small distances air is a better insulator than a liquid dielectric. 3. That the potential at which the bend in the potential-distance curve occurs is the same for air and the liquids operated upon.

*The Dispersion of Silver Chloride:* E. F. NICHOLS and W. S. DAY, Columbia University.

*Properties of Electric Charges on Moving Conductors:* E. F. NICHOLS, Columbia University.

*The Separation of Electric Charges in a Metal by Centrifugal Acceleration:* E. F. NICHOLS, Columbia University.

*Comparative Observations on the Evolution of Gas from the Cathode with the Glow Current in Helium and Argon:* CLARENCE A. SKINNER, University of Nebraska.

*The Effect of Absorbed Hydrogen on the Photoelectric Current:* W. F. HOLMAN, University of Nebraska.

Light from a spark arc between iron terminals in hydrogen was directed through a quartz optical system on to a zinc disk, serving as cathode—a disk of aluminum opposite serving as anode—the electrodes being in a highly evacuated chamber. Under these conditions the rate of leak of negative electricity from the zinc was represented by 32 scale divisions of the measuring instrument.

The zinc was then partially relieved of its supply of hydrogen by use as cathode with the glow discharge in hydrogen, after which it was again tested as before for its photoelectric current, which was found to be now represented by only about 22 scale divisions. This test was followed by using the zinc as anode with the glow discharge in hydrogen, the object of which process was to store up in it a new supply of hydrogen. A test of the photoelectric current as before showed that it had returned to its first value, giving, namely, a deflection of about 32 scale divisions

*The Production of Ozone by Becquerel Rays:* HARRY S. HOWER, Case School of Applied Science.

*The Production of Ozone by the Photoelectric Current in Oxygen:* HARRY S. HOWER, Case School of Applied Science.

*Fluorescence Absorption in Resorufin:* FRANCES WICKE, Cornell University.

*Further Experiments on the Phosphorescence of Sidot Blende:* E. L. NICHOLS and ERNEST MERRITT, Cornell University.

*Magnetograph Records of Earthquakes with Special Reference to the San Francisco Earthquake of April* 18, 1906; L. A. BAUER, Magnetic Survey, Washington.

*Rotation and Elliptic Polarization produced by Iron Films in a Magnetic Field:* W. D. HARRIS, University of Nebraska.

Films were obtained on miscroscope cover glass by cathode deposit *in vacuo*. The rotation of the plane of polarization was measured by use of a Lippich half-shade Nicol prism, and the ellipticity of the light by means of a Brace half-shade elliptic polarizer and compensator. Films deposited in hydrogen exhibited a rotation rising gradually from zero in the violet to a maximum value in the red. The same films showed an ellipticity of the transmitted ray increasing from a zero value in the violet to a maximum at about 600$\mu\mu$, then a gradually decreasing value toward the red end of the spectrum. With age the values for the longer wave-lengths dropped to a marked extent. A film of same density deposited in nitrogen produced a smaller rotation as well as smaller ellipticity, the latter possessing a maximum value at about 560$\mu\mu$. A film deposited in oxygen gave no rotation for any wave-length, but a slight ellipticity, this being a maximum at about 540$\mu\mu$ and dropping rapidly to zero in passing toward either end of the spectrum. All films showed marked polarity when suspended in a magnetic field.

The film deposited in hydrogen tested for variation in ellipticity with the strength of field showed this to be proportional to the field up to about 8,000 C. G. S. units, after which there was but a small increase as the field was intensified.

The reflected light exhibited in no case any observable ellipticity, although three per cent. of that observed in case of transmitted light would have been readily detected.

Cobalt and nickel films deposited in hydrogen showed a rotation similar to iron, but no ellipticity.

*Coefficient of Linear Expansion at Low Temperatures:* H. G. DORSEY, Cornell University.

*New Diffraction Spirals:* A. G. WEBSTER, Clark University.

*The Calibration of Capillary Tubes:* WILLARD J. FISCHER, Cornell University.

*The Latent Heat of Recalescence in Iron and Steel:* FRANK H. BAILEY, Clark University.

*Thermal and Electrical Effects in Soft Iron between* 100° *and* 218°: EDWIN H. HALL, Harvard University.

This will give the results of a continuation of the study which my colleagues and I have already published, in the *Proceedings* of the American Academy for May, 1906. The general method followed has been the same as before and the results obtained are in general accord with those which we have before obtained at a lower temperature.

*Note on Certain Aspects of Drude's Electronic Theory of Metallic Conduction:* EDWIN H. HALL, Harvard University.

I wish to raise the question whether the expansion of metals is to be accounted for by the expansive force of the imprisoned electrons and what effect these electrons should have on the specific heat of metals.

*The Capacity and Resistance of Aluminum Anode Films:* C. MCC. GORDON, Central University of Kentucky.

Films were formed on aluminum anodes with a direct current of known voltage and their capacity measured in the Wheatstone bridge with a small alternating current.

The capacity was found to be practically independent of the electrolyte so long as water solutions are dealt with.

Further experiments by the writer have confirmed the greater thickness of the sulphuric-acid film, as well as the fact that they do not have any smaller capacity than the others. With water-cooled tubular electrodes sulphuric-acid films more than 0.3 mm. thick were formed; but their minimum capacity values were slightly larger than those of other films whose maximum thickness could not have been more than 0.001 mm. Sodium sulphate gives films similar to those in sulphuric acid as to both thickness and capacity.

These results necessitate the conclusion that with the sulphates *the insulating film is not the whole film;* but that we have, superimposed on the insulating film, whose capacity is measurable, a conducting film many times thicker. For solutions other than the sulphates there is no evidence for any such dual-natured film.

The resistance of these films as measured by the Wheatstone bridge with small alternating current is much smaller than the apparent resistance as calculated from the residual direct current.

Bridge measurements were taken both while the direct current was still acting and after it was turned off, while the switching on or off of the direct current made no change in the capacity, the resistance of the films was only about one-third as large with the current on as with it off.

*Spark Potentials between a Point and Plane, for Small Distances:* ROBERT F. EARHART, Ohio State University.

Measurements were made on the P.D. required to cause a spark to pass between a needle point and plane surface. The P.D's were secured from an A.C. transformer and were measured with a Weston voltmeter. No. 10 Sharp needles were used as the point electrode. A large number of needles were examined with a microscope and points approximating a pattern needle were chosen.

Distances separating the electrodes were measured with an interferometer.

Curves representing the relation between spark-potential and distance are similar to those showing the same relation between a spherical electrode and a plane.

For air, at atmospheric pressure the so-called "minimum potential" was found to lie between 290 and 310 volts.

This value does not agree with results secured by other observers from static machines. The value given by Tamm is 2,150 volts when the point is negative and 3,300 for a positive point.

DAYTON C. MILLER,
*Secretary.*

SECTION C.

# CHEMISTRY.

## OFFICERS OF SECTION C.

*Vice-President and Chairman of the Section.*

CLIFFORD RICHARDSON, New York.

*Secretary.*

CHARLES L. PARSONS, Durham, N. H.

*Member of Council.*

J. H. LONG.

*Sectional Committee.*

C. F. MABERY, Vice-President, 1906; CLIFFORD RICHARDSON, Vice-President, 1907; CHARLES L. PARSONS, Secretary, 1904–1908. CLIFFORD RICHARDSON, 1 year; L. KAHLENBERG, 2 years; G. B. FRANKFORTER, 3 years; WILLIAM MCPHERSON, 4 years; W. J. GIES, 5 years.

*Member of General Committee.*

CHARLES H. HERTY.

*Press Secretary.*

C. E. WATERS.

[No formal meeting of Section C was held. Papers intended for this Section were presented before the American Chemical Society and the Society for Chemical Industry.]

SECTION D.

# Mechanical Science and Engineering.

## OFFICERS OF SECTION D.

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*Vice-President and Chairman of the Section.*

W. R. WARNER, Cleveland, Ohio.

*Secretary.*

WM. T. MAGRUDER, Columbus, Ohio.

*Member of Council.*

F. O. MARVIN.

*Sectional Committee.*

F. W. MCNAIR, Vice-President, 1906; W. R. WARNER, Vice-President, 1907; WM. T. MAGRUDER, Secretary, 1904–1908.
H. S. JACOBY, 1 year; H. T. EDDY, 2 years; WM. KENT, 3 years; A. M. GREENE, JR., 4 years; J. B. WEBB, 5 years.

*Member of General Committee.*

G. W. BISSELL.

*Press Secretary.*

WM. T. MAGRUDER.

## REPORT OF THE SECRETARY OF SECTION D.

The meetings of the section were held in the lecture room of Sibley College of Mechanical Engineering and Mechanic Arts, of Cornell University, on Friday and Saturday, June 29 and 30. They were followed by the fourteenth annual meeting of the Society for the Promotion of Engineering Education, an affiliated society of the Association.

In the absence of the vice-president, the retiring vice-president, Fred W. McNair, president of the Michigan College of Mines, acted as chairman of the section. Twenty-three members of the association registered as belonging to the section, while members of other sections attended some of the meetings. Experience gained at this meeting has shown that it is not conducive to the greatest attendance to have Sunday intervene between the meetings of the section and of the affiliated society.

The first two papers were by Byron B. Brackett, professor of physics and electrical engineering of the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. The first paper describes a "Lamp Bank Composed of Small Separate Units." Each unit consists of twelve incandescent lamps arranged in a partially open box, 28 inches long and 10 inches square. The boxes are open enough to give perfect ventilation. On one side are placed switches for cutting in or out the lamps of that particular box, and for changing the grouping of the lamps into parallel, series, or combination arrangements. As many of these units as are desired may be placed one upon the other in tiers, and as many tiers as are needed may be placed side by side to form a lamp bank of any capacity. Each unit is constructed to permit convenient interconnection with the adjacent ones. Thus, the large bank may be separated into smaller ones whenever desired and reassembled with the least possible loss of time and effort for special tests on large machines.

His second paper was on an "Alternating Current Wave-Form Apparatus."

To set the armature accurately for the separate readings in the ballistic method of tracing the E. M. F. wave of an alternator, a double or duplicate brake apparatus is unusually satisfactory. Two similar clamp brakes with ong arms are placed on the pulley side by side. With the arms held rigidly the desired readings for one observation are made. Then brake No. 1 is unclamped at the pulley, the end of its arm released and rotated up a short distance to a fixed spot. Brake No. 1 is now clamped to the pulley, brake No. 2 is unclamped, the end of No. 1 turned down to its original position and No. 2 is clamped again. Thus the armature has been rotated through a small angle, that may be computed with great accuracy from the length of the arms and the distance through which the end of the arm of No. 1 is

moved. The same method may be used wherever small accurate rotations of any shaft are desired and the same apparatus may be used on dynamos, engines, and other forms of machinery.

A report was made by Mansfield Merriman, professor of civil engineering, Lehigh University, South Bethlehem, Pa., on "Constant and Probable Errors in the Estimation of Linear Distances and Vertical Angles, as ascertained by 1,712 Observations on 128 Students."

The observations were made by asking students to record their estimates of the length, width, and thickness of a board, and also of the magnitude of several vertical angles. The angles were estimated in degrees and also by the ratio of horizontal to vertical projection. The following conclusions were drawn:

1. For lengths, about sixty per cent. of the estimates were too large, and the average constant error was always positive.

2. For angles, about eighty per cent. of the degree estimates, and about sixty per cent. of the ratio estimates, were too large.

3. The estimates of vertical angles by the ratio method are more accurate than those by degrees.

4. The probable error of a single estimate is larger than the average constant error.

5. The estimates of the freshmen class had much larger errors than those of other classes.

This interesting example of the application of laboratory methods to the class-room created much interest on the part of the engineering teachers present.

The next paper was read by the secretary, and described and discussed the results of "Some Experiments on the Frictionless Orifice" and was by Horace Judd and Roy S. King, assistant professors of experimental engineering at Ohio State University. The paper is in sequence with one presented by one* of the authors at the St. Louis meeting, on "Pitot Tubes; with Experimental Determinations of the Form and Velocity of the Jets," and which was published in the *Engineering News* of March 31, 1904, page 318.

The experiments described in the paper were made on five frictionless orifices, ranging in size from three-fourths inch to two and one-half inches in diameter. The term "frictionless orifice" is one which has been commonly used in the mechanical laboratory at the Ohio State University for many years. It is the same as what some of the text-books call "an orifice in a thin plate," and indicates that there is no appreciable loss by friction by a stream of water flowing through such an orifice. So far as known, the term was first employed as early as 1873 by Professor S. W. Robinson, emeritus professor of mechanical engineering at the Ohio State University, and will be found on page 552 of Vol. VI of the Geographical Reports of Ohio, 1886, in his report on the "Measurement of Gas Wells and other Gas Streams and the Piping of Natural Gas."

* Science, N. S., Vol. XIX, No., 479, March 4, 1904, p. 364.

The facilities available consisted of a closed standpipe into which several pumps could force water. A horizontal drum was connected near the bottom of the stand pipe, and in the end of the drum the orifice to be tested was secured; the coordinates of the issuing jets were measured by the hydraulic micrometer caliper, described in a paper presented by Professor Wm. T. Magruder at the St. Louis meeting of the association.* The water was caught and measured in a calibrated cistern.

The experiments were made to find:

1. The coefficient of discharge by direct measurement in a calibrated hydraulic cistern, (*a*) to verify existing constants, and (*b*) to find the coefficient of velocity for comparison with that given by the Pitot tube, and (*c*) to verify its constant. The results show a decrease in the coefficient of discharge of 2.5 per cent. with an increase in the diameter of the orifice from three-fourths inch to two and one-half inches. The average value obtained was 0.60664, and is about 1.8 per cent. greater than that given in Merriman's "Hydraulics" (0.5960). Compared with that of Bovey (0.6000), the result obtained with the jet from the one-inch orifice (0.6097) is 1.6 per cent. higher.

2. The shape of the jet in the vicinity of the least section as found by exploring the contour of the jet by the special micrometer caliper. It was that the distance from the face of the orifice to the least section of the jet varied from 1.6 radii for the three-fourths inch orifice to about one radius for that two and one-half inches in diameter. Text-books on hydraulics give this distance as being one radius, while Bazin found no "minimum section" of the jet flowing through a large orifice and under low head.

3. The diameter at least section, as found by the special caliper for four different positions, 45° apart. From the average diameters, the coefficients of contraction were computed, and they were found to decrease from 0.6134 for the three-fourths inch orifice to 0.5955 for the two and one-half inch orifice, with an average value of 0.60674. As calculated from the average results for the coefficients of discharge, the coefficient of velocity is the quotient of the coefficients of discharge and contraction, or 0.60664 divided by 0.60674 equals 0.99983. From this result it is thought that the term "frictionless orifice" is justifiable.

4. The effect of increase of static pressure on least section. No appreciable increase was found in the diameter of the least section of the jet from a one-inch orifice by increasing the pressure from 5 pounds to 100 pounds; and, for pressures as high as 40 pounds, only a slight increase was noticed for the orifices one and one-half inches to two and one-half inches in diameter. This latter was probably due in part to the increased roughness of the contour of the larger streams.

5. The velocity in the least section was found by traversing the jet with a one-fourth inch Pitot tube used in connection with a differential manometer. It is thought that the coefficient of velocity as determined by the Pitot tube is unity within a negligible fraction of 1 per cent. and that the velocity

*Science, Vol. XIX, No, 479, March 4, 1904, p. 364.

is uniform throughout the section. As calculated from the average values of the coefficients of discharge and contraction as determined by experiment, the coefficient of velocity was found to be 0.99983. This compares very well with the average value of the coefficient of velocity, 0.99993, determined by means of the Pitot tube. This would seem to verify the statement that the Pitot constant is unity.

The paper shows that it is the result of most careful and elaborate investigations. It also shows the inaccuracy of certain statements which are still being published in books on hydraulics concerning the vena contracta. While adding new facts to our knowledge, it gives us a method for measuring quantities of water discharged, and with a probable error which is known to be small and less than the probable error of observation. The paper is worthy of careful study and attention. It will probably be published in the *Engineering News*.

The next paper on the program was on "Some Aspects of the Panama Canal," by Wm. H. Burr, professor of civil engineering, Columbia University, New York, N. Y., and a former member of the Isthmian Canal Commission. As the paper has been published in full, and will be found on page 71 of the issue of SCIENCE for July 20, 1906, its contents need not be detailed here. Suffice it to say that the recent dreadful earthquake disaster at San Francisco constitutes the gravest warning in human experience of the advisability of constructing this canal in such a way as to give it the greatest degree of immunity from the results of any convulsions of nature: and the still more recent earthquake shocks on the isthmus should be sufficient to set even politicians to thinking what would be at least one result of an earthquake to the gates and walls of a lock canal having 85 feet of lift.

In this connection it should be noted that while no efforts have been made to secure authors of papers who were in favor of the sea-level canal, yet all the papers which have been presented before this section in the last few years have logically given most excellent reasons why the canal should be built with the fewest possible locks and of the least lift. Time will decide whether the prediction is correct which has been made before this section that the high-lock level will have to be rebuilt before it has been in use ten years.

Henry T. Eddy, professor of engineering and mechanics, University of Minnesota, Minneapolis, Minn., presented a paper on "The Theory of the Flexure of the Symmetrically Loaded Plate, and the Heavy Horizontal Disc of Varying Thickness." Although the theory of the elastic flexure of the thin flat plate of uniform thickness has been long known to the same degree of approximation as that of the common theory of flexure of beams, the theory of the heavy horizontal disc on a vertical axis and of a thickness decreasing from the axis of the rim has, up to the present time, been in a somewhat unsatisfactory state from the point of view of the engineer who would design discs like those employed in the Curtis steam turbine. The object of this paper is to make a contribution to this theory, which it is hoped will facilitate both the algebraic and numerical treatment of such units of construction.

A paper was read and illustrated by Henry S. Jacoby, professor of bridge engineering, Cornell University, Ithaca, N. Y., on the "Applicability of Displacement Diagrams in the Design of the Flanges of Arch Ribs with Solid Webs."

The usual method of finding the stresses in the flanges of arch ribs with solid web plates involves the computation of bending moments and axial thrusts at a number of sections due to dead and live loads, and also when there are less than three hinges, for changes of temperature and rib shortening. The formulas for the determination of the horizontal reactions, while comparatively simple for ribs with a parabolic axis, are complex for a circular axis, and entirely impracticable for other curves such as three or or five centered ovals. The method proposed is to assume the solid web plate to be temporarily replaced by an imaginary inelastic system of open webbing, the panel points of each chord being located in the centers of gravity of the corresponding flange sections. It allows the horizontal reactions to be found by means of displacement diagrams which apply to any form of arch rib. The method also affords the simplest means of finding the deflections under any loading.

"Some Notes on the Teaching of the Cyclic Analysis of the Gas Engine" was next presented by Arthur J. Wood, assistant professor of experimental engineering, Pennsylvania State College, State College, Pa.

As a basis for this study and discussion, the results of tests of a five horse-power gasoline engine were presented in full. The distribution of heat thus obtained is compared with results obtained by an entropy-temperature analysis of one of the indicator diagrams in which the losses are shown graphically. The paper brings out the method for finding the temperature at any point in the card; the heat of the mixture in the cylinder; the average value for the exponent of the adiabatic curves of expansion and of compression and values for different parts of these curves; the method of obtaining the entropy for all points; and a comparison of results of some recent tests at the Pennsylvania State College.

Certain conclusions are drawn from the study of the subject: (1) the losses cannot be computed accurately unless the data are taken more completely and with greater care than is usual with such tests; (2) about 20 per cent. of the heat of the gasoline vapor is available for useful work at full load; (3) the common method of obtaining, by test, the heat in the exhaust gases is not satisfactory; (4) the teaching of the entropy-temperature analysis without requiring the student to make the analysis is a pure waste of time (the average student in the senior class ought to master the whole theory in a few hours, and make the analysis in a few days' time, and this will open to him some of the neatest applications of thermodynamics; a complete analysis by a student is presented in the paper); (5) the value of the exponent of the true adiabatic curve is obtained from the ratio of the specific heat at constant pressure to the specific heat at constant volume and if this curve is constructed it will bring out at a glance where heat is taken in or given out, without resorting to the entropy-temperature dia-

gram. Brief reference is made to the method known as "cylic analysis," in which the principal results as mean effective pressure are obtained from the heat put in, the initial temperature, the value of the specific heat at constant volume and the temperature after compression. The author has found this method to contain nothing attractive as a system for teaching, because, (1) it makes the student a mere machine, substituting in derived formulas; (2) the value of the heat for each cycle can not be obtained accurately by this method; and (3) it does not open up clear, well-defined lines of application of the principles of thermodynamics. The paper as a whole aims to make it clear what data must be obtained in order to make an entropy-temperature analysis and how it may be made practical as a method of instruction and valuable in design. It further shows how the principles of thermodynamics can be made as clear in showing changes of heat energy as of mechanical energy. In all this the writer does not depreciate the value of the purely analytical methods.

The next paper was by W. W. Churchill, vice-president and chief engineer of the Westinghouse, Church, Keer Company of New York, on "The Preservation of Surface Condenser Tubes in Plants using Salt or Contaminated Water Circulation." The paper will be published in full in the October issue of *Power*.

Owing to electrolytic and galvanic action on the tubes of a surface condenser using water containing salt or sewage for circulation, the use of surface condensers in large power plants has been very largely abandoned as useless. Under ordinary circumstances the water bill of such a plant as that described for the Long Island City power house of the Pennsylvania Railroad, containing when fully constructed fourteen 5,500 K.W. generating sets, would be in the neighborhood of $100,000. An investigation was undertaken of possible methods for preventing the rapid destruction of the condenser tubes and parts of the condenser. The most competent opinion that could be obtained was that if the differences of potential due to stray ground traction or other currents could be adjusted to be within three volts or less, the difficulty would cease, as the trouble was due to stray grounded currents from electric railways. To that end the stray currents were measured, and at times a difference of potential of nine volts higher than the harbor was discovered between the railroad rails in the freight yard and the river, producing a considerable flow of current from all parts of the water piping and other metallic substances in the vicinity of the power-house site to the harbor.

In order to properly study the real conditions, a number of glass jars were provided and various combinations of metals were immersed in samples of water taken from the river, of sea water, and of pure water. The action of the river water was much more violent than ordinary sea water. It was further observed that there was a local action going on which was galvanic, and that the amount of stray currents caused the galvanic action to be exceedingly violent, and that thin copper tubes were destroyed at a very rapid rate. They would be punctured in from four to five days, which would

make their use fatal in commercial practice. It is thus evident that there was a violent action between the zinc and copper of the brass tubes which were in contact with the electrolyte. Even when unconnected, or electrically separated, plates of brass were placed in this electrolyte, any projections were promptly destroyed. But if an electric battery having a pressure exceeding that of the couple in the East River water was caused to act to produce a counter current, and having a pressure exceeding that of the galvanic couple, the capacity of this electrolyte to drive off atoms of the mechanically combined metals of the alloys used was overcome and corrosion was arrested. To do this it was planned in this case where this couple is about 0.4 of a volt to put a counter pressure of 0.6 of a volt on the anode. In order to insulate the condenser as much as possible from stray currents from the railway, the joints in the piping and the ground contacts were insulated, and even the large water connections were lined with glass melted onto the surface. To furnish the desired electromotive force a three-K.W. motor-generator was installed and provided with switchboard apparatus and appliances, together with ammeters and voltmeters, and a connection to the outlying anode in the condensing supply intake at its harbor end. This led to considerable discussion as to the methods and reasons why the corrosion was prevented. Reference was made to Faraday's laws, and to the results of the experiments of Helmholtz and Clausius. The best explanation is given in Professor Oliver J. Lodge's "Modern Views of Electricity." All the apparatus was designed in accordance with his theory and statements. Its operation has extended over a period of fourteen months, and with the exception of about ten tubes which have become pitted, the results have been satisfactory. When the condenser was planned, the condenser manufacturer was told to slope the tubes down one inch in the direction of flow; but when they performed the act, they forgot that the middle inclination, if parallel to the first and third passes, would then be uphill for the circulating water, and that when the condenser was shut down all the water would drain out of this middle section except that in the bottom tubes. These bottom tubes, it has been found, have become somewhat corroded, although not seriously.

The cause for this result having now been found, its prevention has been effected by perforating the diaphragm in the condenser head to permit prompt drainage of these tubes when the condenser is taken out of active operation. Considerable difficulty has been encountered in getting the system operated properly at the voltage suitable for the prevention of galvanic action in the hands of the regular operators, as they persisted for a long period in reading amperes instead of volts in adjusting the currents, thus not providing except by accident for the requirements. The efficiency of the apparatus amply justifies the expense of its installation, while its operation is not expensive and the plant here described will now be followed by other protecting plants of the same character.

This paper forms a most excellent illustration of the application of theoretical physics to the solution of a concrete problem in commercial engineering.

The saving of $100,000 a year in water rates at the expenditure of $250, or even more, per year, in a scientific preventive should be a sufficient answer to the commercial man who asks "Does science pay?"

The paper on "The Justification of the Use of the Expression 'Engineering Mathematics,'" by Arthur E. Haynes, professor of engineering mathematics, University of Minnesota, Minneapolis, Minn., describes the conditions as they exist in a large university of the central west wherein mathematics is taught to students pursuing all kinds and classes of courses. The paper will be published in full in the *Proceedings of the Society for the Promotion of Engineering Education.*

The last paper, and in some respects one of the most interesting and valuable papers presented before Section D, was by J. J. Clark, manager of the text-book department of the International Correspondence Schools, Scranton, Pa., on "The Correspondence School: Its Relation to Technical Education, and Some of Its Results." The paper will be published in full in the *Proceedings of the Society for the Promotion of Engineering Education* and will doubtless be abstracted by the technical press.

When Professor Edgar Marburg read a paper* in 1899 on "The Correspondence School in Technical Education" there were about 80,000 students enrolled in the International Correspondence Schools. In the following year this number had increased to 181,000. Owing to a number of circumstances, it was impossible at that time to furnish reliable figures in regard to the work being accomplished. Hence the reports which were made were both unsatisfactory and unjust to the Correspondence School. Since December 31, 1899, the school has grown at a rate of more than 100,000 per annum; the total number enrolled on June 27, 1906, was 902,906. After relating something of the history of the growth of the schools and their methods of securing students, the author describes their system of education as being based on ideas that are almost the direct opposite to those practised by the regular schools and colleges. The regular technical school or college aims to educate a man broadly; the aim of the correspondence schools of the country is to educate him along some one particular line, and to make each course fit the particular needs of the student who takes it. Hence, with a few exceptions, almost every one of the courses is a special course.

The author then describes other methods of conducting correspondence schools by the use of the regular text-books and correspondence concerning the difficulties encountered by the student. The author states that such schools have always failed or made very little progress, "for the reason that the ordinary text-book is not adapted to the use of the person studying by himself." Another method is that of the University of Chicago, where students may take part of their regular college course at home. He cannot, however, get his degree without taking the balance in residence. This plan offers few advantages over the regular college course. The only requirement necessary to become a student of the International Corre-

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spondence School is the ability to read the English language and to write it sufficiently well to be understood, or to possess the services of some one capable and willing to translate from the text-books and write out the dictation in English of the foreign-speaking student who is unable to use the English language.

The text-books differ, even on the same subject for the courses for which they are to be used; not only on the method of treatment, but principally in the examples given and the illustrations cited.

The author gives a number of reasons why students do not complete their courses, and also mentions cases of students who admit deriving much benefit from the course but who have never submitted an examination paper for correction. Their instruction has been obtained solely from the bound volumes which were furnished them when they enrolled. About 60 per cent. of the students send in one or more pieces of work. About two-thirds of the students pay in full for their courses. While the present enrolment is a little over 900,000, the actual number of students is probably 60 per cent. of this, or 540,000. During the year ending May 31, 1906, the total number of pieces of work received from students was 716,952. About one-third of the number of active students have completed about one-third or more of their course as shown by the records. The number of students who have entirely completed their courses, passed their final examinations, and been awarded a certificate or diploma, was 12,143 on June 27, or about 2.6 per cent. of the total number of active students. Between February 7 and April 21 the number of diplomas issued averaged 240 per month. The average for next year is estimated as high as 300 per month, or 2,700 diplomas for the year from this one correspondence school. As this number is about the same as the number of engineering degrees conferred per annum by all the technical colleges of the country, the amount of work that this represents, and the amount of education which is being obtained, can be somewhat appreciated.

The social sides of the meeting were very well cared for by the committees of Cornell University, and have been described in the report of the general secretary. A special excursion was tendered to the section by the committee on Saturday afternoon in the form of a steamboat ride on the steamer *Iroquois*, down the lake, and which included a visit to the Remington Salt Works near Ithaca. Here steam is generated and used in steam engines for the generation of electric power, and the exhaust steam is used in the vacuum pans of the salt works. A feature of the meeting which appealed to every one was the delightful entertainment accorded to the members in the houses of the fraternities. Altogether the meeting was most enjoyable and profitable, and both the section and the Society for the Promotion of Engineering Education desire to extend their special thanks to the trustees, the faculty, and to the fraternities who opened their houses at Cornell University.

WM. T. MAGRUDER,
*Secretary.*

SECTION E.

# Geology and Geography.

## OFFICERS OF SECTION E.

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*Vice-President and Chairman of the Section.*

A. C. LANE, Lansing, Mich.

*Secretary.*

E. O. HOVEY, New York, N. Y.

*Member of Council.*

C. R. VAN HISE.

*Sectional Committee.*

WM. NORTH RICE, Vice-President, 1906; A. C. LANE, Vice-President, 1907; E. O. HOVEY, Secretary, 1904–1908.
I C. RUSSELL, 1 year; C. R. VAN HISE, 2 years; I. C. WHITE, 3 years; F. P. GULLIVER, 4 years; E. H. BARBOUR, 5 years.

*Member of General Committee.*

E. H. BARBOUR.

*Press Secretary.*

L. C. GLENN.

## REPORT OF THE SECRETARY OF SECTION E.

The section organized at 11 A. M., Friday, June 29, directly after the adjournment of the first general session of the association, in the geological lecture room, McGraw Hall, with vice-president and chairman A. C. Lane in the chair and thirteen members and seven visitors present.

Before proceeding with the program of papers the following preamble and resolution were offered by Mr. George H. Chadwick, of Albany, New York:

Whereas in the decease of Professor Israel C. Russell Section E has lost an efficient officer and one of its foremost workers and best loved members.

*Resolved*, That the section express its deep sorrow and its sense of the great loss to geologic science through the event.

Remarks to the motion were made by Messrs. A. C. Lane, H. S. Williams, D. S. Martin and E. O. Hovey

The following papers were then read in accordance with the printed program:

*Revision of the Geological Section passing through Ithaca, N. Y.*: Professor H. S. WILLIAMS, Cornell University. (By permission of the Director of the U. S. Geological Survey.)

The author explained that the revision of classification and nomenclature proposed was the result of the formations examined in preparation of the map and folio of the Watkins and Catatonk Quadrangles now in preparation. The section is the standard section of the New York Devonian as originally defined and described by Vanuxem and Hall in 1842–1843. The revision of the classification and nomenclature is based upon a critical study of the composition, sequence and range of the fossil faunas of the Watkins and Catatonk Quadrangles. The thicknesses are estimated as for a generalized section passing through the rocks at Ithaca, N. Y.

The taxonomic classification into series, formations, members and lentils, is in accordance with the rules of the U. S. Geological Survey published in the 24th Annual Report for 1902–1903.

The following chart expresses in brief the classifications and nomenclature presented, the new names having been accepted by the committee on geologic names of the U. S. Geological Survey.

SCHEME OF CLASSIFICATION AND NOMENCLATURE OF THE GEOLOGICAL SECTION PASSING THROUGH ITHACA, N. Y.

| | Formations. | Members and Lentils. | Section. | Thickness. |
|---|---|---|---|---|
| Erie (division or) series of Vanuxem. | *Chemung.* Shale and sandstone formation. | *Fall Creek conglomerate lentil.* | | 0–10 ft. |
| | | *Wellsburg* sandstone member. | | 600–650 ft. |
| | | *Cayuta* shale member. | | 600 " |
| | *Nunda.* Shale and flagstone formation. | *Enfield* shale member. | | 550–800 ft. |
| | | *Ithaca* shale member. | | 80–300 " |
| | | *Sherburne* flagstone member. | | 188–260 " |
| | *Genesee.* Shale formation. | | | 125 ft. |
| | *Tully.* Limestone formation. | | | 10–30 ft. |
| | *Hamilton.* Shale formation. | | | 1,035 ft. |
| | *Marcellus.* Shale formation. | | | 125 ft. |
| | *Onondaga.* Limestone formation. | | | 125 ft. |
| | *Oriskany.* Sandstone formation. | | | 0–4 ft. |

The principal changes affecting nomenclature are the following: viz., the *Nunda shale and flagstone formation* is the stratigraphic equivalent of Hall's Portage or Nunda group, the standard section of which is found in the Genesee Valley. The term Portage was used by Hall for the sandstone member at the top of his Portage or Nunda Group as well as in the name of the other group. Of the two synonyms the first (Portage) is left to be applied in its specific sense to the Portage sandstone member, and Nunda is retained for the formation name.

The lithologically discriminated members of the Nunda characteristic of the Genesee Valley section (*i. e.*, Cachaqua, Gardeau and Portage) are not distinguishable in the Ithaca section. The subdivisions in the latter section are the *Sherburne flagstone*, the *Ithaca shale* and the *Enfield shale members*. The first of these is the equivalent of the Sherburne flagstone of Vanuxem; the second is the typical Ithaca group of Hall and later writers; the third is the "upper part of the Portage" of the classification proposed by Williams in 1884; and the name *Enfield* is applied for the name of the town Enfield where the member is typically exposed.

The boundary between the Nunda and Chemung formations is established on the basis of change in the generic composition of the faunas occurring at the horizon indicated. The two genera *Dalmanella* and *Douvillina*, and

the species *Spirifer disjunctus* are among the more characteristic of the forms marking this change. The *Cayuta shale member* contains the typical Chemung fauna of the Chemung Narrows section; it is paleontologically limited by the Nunda fauna below, and by the fourth of the known zones of *Tropidoleptus* appearing above the Hamilton formation, to which the name *Swartwood Tropidoleptus zone* has been applied by the author for the outcrop southwest of Swartwood at an altitude of about 1,600 feet A. T., containing the fauna.

The name *Cayuta* is applied for the Cayuta Creek, along the sides of which from Cayuta Lake to its discharge into the Susquehanna River typical exposures of the Cayuta member may be seen.

The second member of the Chemung is named *Wellsburg sandstone member* for its outcrop at Wellsburg and above in the hills of Ashland. It is paleontologically discriminated by absence of many common Chemung species and lithologically by the more sandy nature of the rocks; and the thin-bedded slabs characteristic of the higher "Catskill" rocks are conspicuous in the upper portion.

The Wellsburg member is terminated above by the *Fall Creek conglomerate lentil*, a thin band of conglomerate discovered in place at the top of the Ashland Hills and frequently visible in detached pieces on tops of other hills along the southern townships of the state.

The Fall Creek conglomerate lentil is interpreted to be the equivalent of the conglomerate of that name in Bradford and Tioga Counties, Pennsylvania. In the beds immediately under the conglomerate, and terminating the Wellsburg member, occur in great abundance the shells of *Leptostrophia nervosa* and *Orthothetes chemungensis*. To distinguish this particular horizon the name *Ashland Leptostrophia zone* has been applied to the zone by the author. The author stated that other evidence obtained by comparison of this section with others indicates that the highest stratigraphic extension of the Chemung fauna is not reached at the top of the Wellsburg member, but that to the west and south of this section rocks stratigraphically still higher may bear many of the species of the Chemung formations.

Professor Williams's paper was discussed by Messrs. J. C. Branner, C. A. Hartnagel and D. S. Martin.

*Abyssal Igneous Injection as a Causal Condition and as an Effect of Mountain Building:* Dr. R. A. DALY, International Boundary Commission, Ottawa, Canada. (Illustrated with a diagram.)

The contraction theory of mountain building is hypothetically extended to cover the explanation of igneous intrusion, geosynclinal down-warps, the location of mountain ranges, and the common association of intense mountain building with the batholithic intrusion of magma. Among the chief postulates are: (1) an earth-crust about twenty-five miles thick, overlying a substratum which, on account of its high temperature, acts as a viscous liquid; (2) the division of the crust into a shell of compression about five

miles thick, overlying a shell characterized by cooling tension. The shell of tension extends from the bottom of the shell of compression down to the substratum.

One effect of cooling tension is to produce cracks in the lower shell; these are only partly closed by the shearing of masses against masses. Because of the solid continuity between the two shells, some of the tension remains unrelieved.

Tension in the lower shell permits of the abyssal (dike) injection of the substratum fluid into the crust. This injection is especially facilitated in earth-zones established by cosmical stresses. The hydrostatic and expansional pressures normal to the walls of such an abyssal dike cause lateral creep and special condensation of matter in the shell of tension. This movement induces a down-warp of the earth's surface overlying the zone of injection. When the down-warp is of large size it is a geosynclinal. Its sedimentary filling is accomplished through the shearing of the shell of compression over the shell of tension. This breaking of the solid continuity between the two shells releases all the accumulated tension. As a result, extraordinarily large bodies of magma are injected from the substratum into the shell of tension beneath the mountain-range. The assimilation of the folded rocks of the range leads to the formation of granitic batholiths.

Dr. Daly's paper was discussed by Messrs. A. C. Lane, J. C. Branner and D. S. Martin.

*Brewsters Neck, Connecticut:* Dr. F. P. GULLIVER, Norwich Town, Conn. (Abstract read by E. O. Hovey.)

Brewsters Neck, Conn., is a deposit of water-laid sand and gravel lying between the preglacial valley of the Thames River, and the preglacial tributary which may be called the Poquetanock River.

The surface of this deposit rises from 70 to 85 feet above the level of the tide water as it exists to-day. It lies from 100 to 150 feet above the level of the bed of the preglacial Thames River.

On the east and west sides of this deposit there is a steep slope. On the north side the surface of the deposit comes directly against the bed-rock, which at this point is covered with a thin deposit of till not completely masking the ledges which appear at various places.

On the northwest corner of this deposit there are distinct lobes projecting toward the northwest and between these lobes and the bed-rock slope to the north, which is very steep at this point, there is a deep hollow which is popularly called a "valley." The form of this "valley" shows conclusively that it was not formed by degradation, but by aggradation.

On the southeast corner of this deposit the surface merges gradually into the gentle slope of a low hill, which is bed-rock covered with till. West of this hill is a confused mass of kames and kettle-holes which are beneath sea-level, and since these are now filled with water they are used for floating lumber for the Dawley Lumber Yard at Fort Point.

Perhaps the most interesting point along the margins of these depos ts lies just above these two salt-water ponds, which fill these kettle-holes. The surface of this deposit, which the author would name a *delta-terrace*, slopes from the northeast, where the highest point is 85 feet above the level of the sea, toward the southwest, where the surface is about 70 feet. The deposit is undoubtedly a glacial delta. Its distinct lobes and structure are typically that found in deposits laid by a stream emptying into standing water. It is very similar to the structure reported by the author of this paper as occurring at the Navy Yard, above New London.*

A new point in regard to the theory of the formation of water-laid glacial deposits is believed to be as follows: When the margin of the ice-sheet was retreating by the annual summer melting faster than ice was supplied, the ice remained longest in the valleys. Masses of ice would thus be left in the deeper valleys which would rise many feet above the surrounding hills. Between these ice masses standing water would occur either as arms of the ocean or as ice-dammed glacial lakes between these ice-blocks. In these bodies of standing water the streams from the melting ice would deposit their sand and gravel, and at the point where the streams issued from the ice there would be eskers and ice-contact slopes. These latter deposits would contain the larger materials, and the fine sand would be found farthest from the point where the streams issued from the ice. Where the supply of rock waste was sufficient to fill up the space lying between these ice-blocks, a flat-topped delta-terrace would be formed; where the supply was not sufficient to fill up the water body, lobes would occur. These lobes would project into the water body, and from the axis of the arched layers as shown in sections, the direction of flow taken by a given glacial distributary may be discovered.

In this deposit, therefore, the lobes at the northwest corner show that the sand of which they are built was coming from the southeast. The arched layers shown in the sections at the southwest corner of this deposit indicate that the material there found came from the northeast. Other sections of this delta-terrace at Brewsters Neck, as revealed by the excavations made for the State Hospital, show that in the center of the deposit there were alternating currents coming from both the east and the west.

The author believes from the facts shown by these recent cuttings and from the facts which have long been recognized from the surface form, that this deposit was built by streams issuing from two blocks of ice, one of these blocks occupying the valley of the glacial Thames, the other occupying the valley of the tributary of the Thames River which flowed through the Poquetanock Valley. The slope of the surface of this delta-terrace indicates that the last source of the material was from the Poquetanock ice-block on the east.

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*"Thames River Terraces in Connecticut," *Bull. Geol. Soc. Am.*, Vol. 10, 1898, pp. 492–494.

*Notes on the Geology of the Guaynopita, Chihauhau, Mexico, Mining District:* Dr. E. O. HOVEY, American Museum of Natural History of New York. (Illustrated with lantern slides.)

The Guaynopita district lies in the heart of the Western Sierra Madre in northern Mexico. It shows a series of Cretaceous limestone and schist and gneiss overlain by volcanic rocks (andesites) and invaded by granite intrusions. Later volcanics (basalt, andesites and rhyolites) have supervened, basins have been filled with sandstones and conglomerates, and the whole region has been deeply dissected by the Aros and its tributaries.

Dr. Hovey's paper was discussed by Messrs. A. C. Lane and C. R. Dryer.

*The Relations of the Drainage of the Santa Clara Valley, California, to that of the Pajaro River:* Professor J. C. BRANNER, Stanford University.

Several years ago Dr. Joseph Le Conte advanced the theory that the drainage of the Sacramento Valley of California formerly entered the Pacific Ocean through the Bay of Monterey instead of through the Golden Gate as it does at present. This theory was based chiefly upon the absence of a submerged channel outside of the Golden Gate and the presence of such a channel in the Bay of Monterey. Later, the study of the fish faunas of the streams of California by Professor C. H. Gilbert and his colleagues showed that there had formerly been some connection between the Sacramento, the Coyote, the Pajaro, the Salinas and various other streams that are now separate. These faunal relations seemed to give strong support to the theory of the newness of the Golden Gate channel.

Later study shows that the mingling of these faunas may be explained otherwise. During the glacial epoch the region in question stood from 2,000 to 3,000 feet higher than it does at present. The Bay of San Francisco did not then exist, but the Sacramento and Coyote drainage flowed through it. Coyote Creek rising on the western slope of the Mt. Hamilton range flowed into the Santa Clara Valley at the top of the watershed between the present Coyote Creek and the Pajaro drainage. An alluvial cone was built up on the flat valley-floor where the Coyote emerged on the plain of the Santa Clara Valley. As this cone grew the Coyote swung from side to side, emptying its waters now into the Bay of San Francisco and now into the Bay of Monterey. Fishes ascending from the Sacramento into the Mt. Hamilton range could later descend into the Pajaro drainage. The elevation of the coast at that period carried the mouth of the Pajaro farther toward the west, so that fishes could pass from the Pajaro into the San Lorenzo and into the Salinas without entering the sea.

The depression following the glacial epoch submerged the mouth of the Sacramento forming the Bay of San Francisco, and separated the San Lorenzo from the Pajaro and the Salinas Rivers. The decreased precipitation diminished the volume of Coyote Creek and it ceased to build the cone near Madrone Station, and since then it has flowed toward the Bay of San Francisco and has been cutting into its alluvial cone.

Professor Branner's paper was discussed by Messrs. T. C. Hopkins, C. R. Dryer, A. C. Lane, George H. Chadwick and E. O. Hovey.

*The Geology of Coon Butte, Arizona:* Messrs. D. M. BARRINGER and B. C. TILGHMAN, Coon Butte, Arizona. (Illustrated with diagrams and specimens and presented by J. C. Branner.)

Coon Butte, Ariz., is a low crater-like hill six miles south of Sunshine Station on the Santa Fe Railway, and about twenty-five miles southeast of Flagstaff. The general geology of the surrounding country is very simple, consisting of horizontal beds of red sandstone, silicious limestone, white sandstone and light brown sandstone, each bed being clearly distinguished from the others. In this plain is a pit about 600 feet deep and three quarters of a mile across. The edges of the beds exposed in the pit are all turned sharply upwards. The slopes of the ridge around the pit are covered with blocks and fragments of rocks like those exposed within the pit. Several years ago Mr. G. K. Gilbert made a study of Coon Butte. He appears to have supposed at first that it was formed by a meteor striking the earth. His final conclusion was, however, that it was caused by a steam explosion.

Some years ago a mining company, acting upon the theory that the Coon Butte pit was made by a meteor, began a systematic search for the mass in the bottom of the crater-like depression. Their explorations show that the region has yielded several tons of meteoric iron, and that a large number of pieces of this iron have been found interbedded with the débris thrown from the pit. The distribution of the irons on the surrounding plain also lends strong support to the idea that the depression was made by a meteor striking the earth. The bottom of the pit is filled with fossiliferous fresh-water deposits to a depth of about eighty feet.

Messrs. Barringer's and Tilghman's paper was discussed by Messrs. J. C. Branner, A. C. Lane and E. O. Hovey.

Recess was taken from 12:45 to 3:45 on account of lunch and the dedication of Rockefeller Hall.

Saturday, June 30. Excursion to Union Springs under the leadership of Professor G. D. Harris, of Cornell University. This was participated in by thirteen members of the section. The stratigraphy, paleontology and physiography of the region were studied.

Monday, July 2. An excursion by boat to various points of interest at the southern end of Cayuga Lake under the leadership of Professor G. D. Harris, which was participated in by eighteen members of the section and association. The succession of Devonian beds along the lake shores was noted, peculiarities of shore-line and delta formations observed, and the erosion of the strata as exemplified in the Taughannock Falls studied. The Glenwood intrusive dike was visited.

Tuesday, July 3. An excursion to Enfield Glen under the leadership of R. H. Whitbeck of the State Normal School, Trenton, N. J., which was participated in by fifteen members of the section and association. The glacial phenomena of Cayuga Valley, the geology of the lateral valleys, the jointed structure of the rocks and the Enfield Falls, were the natural features of particular interest.

After lunch at the Enfield Glen, Professor C. R. Dryer, of the State Normal School, Terre Haute, Ind., gave, by invitation, a carefully prepared paper upon "The Geologic Features of the Finger Lake Region, New York."

Western New York may be divided into four physiographic regions: (1) the Iroquois plain, (2) the drumlin belt, (3) the Finger Lake belt, (4) the Allegheny Plateau. The Finger Lake belt lies on the northward slope of the plateau and is trenched by numerous north-south valleys, many of which contain lakes. The valleys are long, narrow, straight or but slightly curved, flat-bottomed, from 1,500 to 2,500 feet deep and partly filled with sediment. The rock floor of the Cayuga Valley is 55 feet below the sea level and that of the Seneca Valley at least 556 feet. The slopes of the valley walls are smooth, symmetrical, devoid of spurs, and below the 900-foot level are sharply oversteepened. The wide, open, mature valleys of the tributary streams are, with a few exceptions, "hung up" at the edge of the steepened slope and the streams drop by rapids and falls through narrow rock gorges, to the lake level. Enfield Creek has in its upper course a fall of about 30 feet to the mile, then it makes a nearly vertical fall of 210 feet and descends 450 feet in one mile and a half to the level of Cayuga Inlet. If the slope of the upper part be extended out into the air it would pass 500 feet above the present mouth of the stream. Within sight on the southern horizon is a notch or gap 600 feet deep and one-fourth of a mile wide which leads from the head of this stream through to the Chemung drainage without any definite divide.

The physiographic problems of this region are many, but the features just enumerated can have but one meaning. Main valleys oversteepened, overdeepened, and too straight and smooth to be the work of streams alone, tributary valleys hanging hundreds of feet above their immediate base-level, a main divide notched by through-going gaps—these are as characteristic of glaciated and ice-shaped regions as the features of Alaska, the Alps, Norway or New Zealand. In face of the fact that such peculiar, strongly marked and abnormal features always occur concordantly in regions known to have been extensively glaciated, any other hypothesis than that they are due directly or immediately to ice action of some kind seems gratuitous and impertinent. To set up such trifles as a patch of residual soil, an island in the lake, a shore cliff, etc., as competent to negative the evidences of glacial erosion is to swallow gnats and strain out a camel. A gnat may be as difficult to explain as a camel, but it is of relatively little consequence whether he is explained or not. As a means of progress across the desert of hypothesis to the oasis of conclusion, the camel may be relied on and the gnats that annoy him disregarded.

The various sessions and excursions of the section were attended by thirty different members of the association.

The section finally adjourned at about 4 P. M., Tuesday, July 3.

EDMUND OTIS HOVEY,
*Secretary.*

SECTION F.

# ZOOLOGY.

## OFFICERS OF SECTION F.

*Vice-President and Chairman of the Section.*

E. G. CONKLIN, Philadelphia.

*Secretary.*

C. JUDSON HERRICK, Granville, Ohio.

*Member of Council.*

HERBERT OSBORN.

*Sectional Committee.*

HENRY B. WARD, 2d Vice-President, 1906; E. G. CONKLIN, Vice-President, 1907; C. JUDSON HERRICK, Secretary, 1906–1908.
C. H. EIGENMANN, 1 year; H. B. WARD, 2 years; FRANK SMITH, 3 years; W. F. RITTER, 4 years; A. M. BLEILE, 5 years.

*Member of General Committee.*

B. L. SEAWELL.

*Press Secretary.*

C. JUDSON HERRICK.

## REPORT OF THE SECRETARY OF SECTION F.

Section F at the Ithaca meeting held joint sessions for the reading of papers with the American Microscopical Society, June 29 and 30. The following papers were read under the auspices of Section F.

*Chromosome Relations in the Spermatocytes of Oniscus:* M. LOUISE NICHOLS University of Pennsylvania.

In the equatorial plate of the first maturation division, chromosomes differing from each other in shape may be discovered. They are of three kinds: First, straight or dumb-bell-shaped, in which the halves of the bivalent chromosome lie end to end; second, curved or crescent-shaped, in which the halves lie end to end but with the extremities curved toward each other; third, a form in which the halves lie side by side. In each type a split may be seen running the length of the individual chromosome and the first division is reductional. In the prophases of the first maturation division, chromosomes of the first and second types are present as straight or curved rods; the third type is represented frequently by rings, complete or nearly so, occasionally by V-shaped structures. The reduced number of chromosomes, as far as could be determined, is sixteen. Of this number, two have the ring form in the prophase, two the crescent form, while the remainder are straight or dumb-bell shaped. The chromosomes vary somewhat in size, but the differences are not strikingly great. The largest have the ring form, but the smallest are straight. A tendency to localization in the nucleus is observable. The ring forms usually lie on opposite sides of the nucleus, separated by a crescent. Similarly the crescent forms lie on opposite sides with a ring between.

*Notes on the Poison Organs in Fishes:* H. D. REED, Cornell University.

Axillary poison glands are found in all species of *Noturus* and *Schilbeodes*. In *S. gyrinus* and *S. nocturnus* poison glands are found enveloping the pectoral and dorsal spines. Wherever found these glands are invaginations of the skin, in which respect, as well as in structure, they are identical with the poison organs of the weever fishes.

*Exhibition of Bird Drawings:* L. A. FUERTES, Ithaca, N. Y.

*Exhibition of and Remarks upon Certain Rare or Unique Specimens in the Cornell University Museum of Neurology and Vertebrate Zoology* BURT G. WILDER, Cornell University.

Among the specimens are the smallest recorded manatee fetus; a human

embryo about 4mm. long attached to the vitellus; an embryo shark with undivided cerebrum; the brain of the anguin, or frilled shark, presenting the indifferent relation of the cerebral and olfactory portions more nearly than in any other known vertebrate; the brain of *Ceratodus*, presenting the characteristic dipnoan ventral cerebral extensions; the brains of *Tarsius*, *Cheiromys* and all the anthropoid apes; the brain of the manatee; the brain of a sheep with defective callosum and fornix, and that of a cat lacking these parts altogether; that of a child born at term with the cerebral hemispheres in the fetal condition of large cavities and thin parietes; an adult human brain with an extra precommissure; the brains of two philosophers and mathematicians differing markedly, and that of a mulatto resembling one of the former; the brain of a dentist presenting two self-inflicted pistol-ball wounds; the separable dental laminæ of a young elephant; mastodon teeth and bones from near Ithaca; the brains of some rare Japanese sharks.

*Sex Differentiation in Dinophilus:* EDWIN G. CONKLIN, University of Pennsylvania, Philadelphia.

Korschelt (1882) discovered that *Dinophilus apatris* lays two kinds of eggs, the one three times the diameter of the other; and he further determined the important fact that the small eggs invariably develop into males and the large ones into females. He did not, however, study the oogenesis of these two kinds of eggs. The occurrence some years ago of a related species of *Dinophilus* in the marine aquaria at the University of Pennsylvania gave me an opportunity to study this problem.

The earliest stages in the developing ovary of *Dinophilus* which I have examined show only one kind of primitive egg-cells or oogonia. These cells are very small and details of their structure are not readily made out, but all are approximately of the same size. The size and structure of these cells and of their nuclei are apparently the same in all cases. I have repeatedly seen the last oogonial division, but the chromosomes are so small and numerous (about 20) that it has not been possible to distinguish any constant difference either in the number or in the shapes of these chromosomes.

After the oogonia have entered upon the growth period and have reached about twice their original diameter they begin to fuse together and in this process at least twenty-five or thirty fuse to form the female eggs, while a much smaller number fuse to form the male eggs, a fact recently reported by R. Hertwig (1905). In the fusion, the cell boundaries first disappear and then some time later the nuclear membranes dissolve and the nuclear contents are scattered in the cell, where they slowly dissolve. Only one nucleus remains in the syncytium; this is in most cases centrally placed, but I have been unable to determine whether its survival depends upon its position or upon some intrinsic difference.

In the fully formed ovarian eggs the nucleus of the small eggs is relatively larger than that of the large ones, as R. Hertwig (1905) has stated, the

relative diameter of the nucleus to the entire cell being about 1:4 in the case of the male eggs and about 1:6 in the case of the female eggs. In this fact Hertwig thinks we have the cause of sex determination. It is doubtful whether this can be accepted as a general explanation, and even in the case of *Dinophilus* it is not certain that it is the true explanation. The relatively greater size of the nucleus in the male eggs is probably due to the smaller number of cells which fuse to form the cell body, and this may result from the relative isolation of the male eggs as compared with the crowding of the female eggs.

In the first maturation division the chromosomes, though small, may be counted, and it is found that there are ten in both male and female eggs. No differences in the size of individual chromosomes can be detected in the two kinds of eggs.

The manner in which the primary oocytes fuse together to give rise to the male or female eggs suggests that the position of the eggs in the ovary and their relative isolation or crowding may here be the sex-determining factor.

*Glycogen in the Nervous Tissue of Embryo Mammals, with Demonstration:* SIMON H. GAGE, Cornell University.

From the first discovery of glycogen in animal tissue by Claude Bernard in the fifties until the present time, all investigators assert that glycogen is not present in nervous tissue at any stage of development or during any state of activity. In the summer of 1904, while at the Bermuda Biological Station, *Amphioxus* material was fixed in absolute alcohol for the determination of glycogen. Abundant glycogen was found in the large nerve cells of the central nervous system in both *Amphioxus* and *Asymmetron*. From this discovery it was believed that glycogen would probably be found in the nervous tissues of mammals if they were taken at the right time. A series of pig embryos from 7 to 70 mm. was sectioned and plentiful glycogen was found in the cells of the dorsal ganglia in embryos from 7 to 20 mm. In the 20 mm. embryo glycogen was also present in the developing nerve trunks, and in older embryos it nearly or quite disappeared from the ganglion cells but became exceedingly abundant in the nerve trunks. These facts point to the conclusion that at some period in the growth of nervous tissue glycogen plays as important a part as in the other tissues of the body.

*The Notochord of the Head in Human Embryos of the Third to the Twelfth Week, and Comparisons with Other Vertebrates:* SUSANNA PHELPS GAGE, Ithaca, N. Y.

In the Cornell collection are many sagittal series which are especially favorable for the study of a mesal organ like the notochord. In a human specimen of sixty days the relations of the notochord to the cartilaginous base of the skull and the epithelium of the mouth are clear. On emerging from the axis, it forms a knotted protuberance dorsal of the base of the

skull, passes diagonally through it to a pocket from the roof of the mouth, thence cephalad to come in contact with two other mouth pockets, thence diagonally dorsal through the base of the skull, again forming a knot and turning sharply ventral, ending near the hypophysis but within the cartilage.

The same relations exist in a specimen of forty-eight days in which the base of the skull is not as far from the roof of the mouth and the excursion of the notochord is not so far ventrad.

At thirty-six days the condensed mesoderm foreshadows the skull, and the same general relations occur, the ventral excursion of the notochord being very limited and touching the straight roof of the mouth in three or four loops.

At twenty-eight and twenty-one days the notochord lies directly in contact with the epithelium of the roof of the mouth, thus showing the beginning of the history. Transactions verify the above observations.

The comparative study of pig, sheep, calf, mouse, cat, chick, amblystoma, frog, shark and lamprey shows that the notochord after the earliest stages is usually completely separated from the roof of the mouth, being included in the more condensed tissue forming the skull and taking a straight course. In the pig, however, about twenty per cent. were similar to man, being in contact with mouth pockets.

In the calf, contrary to the observation of Froriep, the specimen examined showed the usual straight form.

The cephalic tip of the notochord in the above mentioned examples varies in relation, being in contact with: (*a*) the hypophysis (ingrowth of skin); (*b*) Sessel's pocket (outgrowth of enteron); or (*c*) the first mesodermic head cavity (derivative from enteron). The last condition, found in shark, may be the typical one.

*Importations of the Gipsy Moth and Brown-tail Moth Parasites from Europe:* L. O. HOWARD, U. S. Department of Agriculture.

In the late spring of 1905 the state of Massachusetts appropriated ten thousand dollars a year, for three years, to be expended in an effort to import into the United States the European parasites of the two destructive insects mentioned in the title. The larger part of this appropriation, together with a small appropriation of twenty-five hundred dollars, made by the general government, was used and is being used in this attempt, the whole European end of the effort having been placed under the control of the speaker.

In June, 1905, he visited Europe, landing at Naples on the fifteenth of that month. At the time, the south European brown-tail moths had all issued, and the gipsy moth was in the full-grown caterpillar stage. Arrangements were made with experts in Italy, in Austria, in Hungary, in South Germany, Switzerland and France to send to Boston full-grown larvæ and pupæ of the gypsy moth; and full instructions were given as to methods of shipment. During the following summer months very many

specimens were received in Boston and were cared for in a temporary laboratory at Malden and a number of different species of parasites issued, the most promising ones being tachina flies. These over-wintered successfully in Massachusetts, and a certain proportion of flies issued from the over-wintering puparia the present spring.

In April, 1906, the same journey was practically repeated, the speaker visiting first France, then Italy, then Austria and Hungary, and afterwards Germany and Switzerland, and arrangements were made, at an earlier period in the season, so that much larger quantities of both species will be secured. Shipments from many points in Europe are already being received and many parasites are being bred from European specimens of both species.

The most interesting feature of the effort so far has come through the wholesale introduction of the over-wintering nest of the brown-tail moth. On the strength of an unpublished observation of Jablonowski, of Budapest, mentioned to the speaker in July, 1905, no less than one hundred and eighty-five thousand nests were imported into Massachusetts from forty different localities in Europe, ranging from Rennes on the northwest to Budapest on the southeast. From these nests were bred the present spring and early summer many thousands of specimens of parasites of different groups; these have been colonized in the open and in out-door cages constructed of wire gauze and placed over good-sized trees thoroughly infested with both gipsy moth and brown-tail moth larvas.

The interesting feature of the experiment is the large scale upon which it has been conducted. Earlier attempts to introduce and acclimatize beneficial species from one part of the world into another have been done on a small scale; but comparatively few have been imported at any one time. In this instance the experiment was so perfectly safe and the country into which the forms wer eintroduced was so extensively ravished by the insects that the introduction of additional pests of the same species could possibly do no harm; whereas, by such wholesale introduction, vastly greater numbers of the parasites would be secured, thus promising earlier relief than by the other method.

*On the Connections of the Funicular Nuclei of the Brains of Fishes:* C. JUDSON HERRICK, Denison University.

In those teleosts which possess elaborately developed taste bud systems in the outer skin, we find that the entire taste bud system of nerves, including nerves from sense organs in the mouth and pharynx and also from similar organs in the outer skin, is very intimately connected with the viscero-motor nervous apparatus, as was to have been expected. But the terminal nuclei of the nerves from taste buds in the outer skin, which unquestionably belong morphologically to the visceral sensory system, have extensive additional sensory connections with distant motor centers of the somatic type. These long reflex gustatory paths are of relatively recent phylogenetic origin and in some teleosts are very elaborately devel-

oped. The connections in the mid-brain of the ascending secondary gustatory path I have described in a previous communication. In this paper I have analyzed the descending secondary gustatory path and found that in its further course and connections in the funicular nucleus region it has all of the functional characteristics of a somatic reflex arc—from cutaneous organs of taste to somatic muscles. This is a point of considerable theoretical interest as a concrete illustration of the way in which the most rigid morphological lines may be crossed by the exigencies of functional adaptation.

*The Hackled Band in the Webs of Certain Spiders:* J. H. COMSTOCK, Cornell University.

It is well known that those spiders which possess a cribellum and a calamistrum spin two kinds of silk: one, a simple smooth thread of the ordinary type, and another that presents a curled appearance. Photomicrographs of the silk of representatives of three families of cribellate spiders were presented. In each the characteristic silk consists of a ribbon-like structure which, on account of the manner in which it is made, may be termed the hackled band. In each case the hackled band consists of two elements: a series of longitudinal threads, which may be termed the warp, and a sheet of viscid silk supported by the warp, which may be termed the woof. In the hackled band of *Uloborus* and Hyptiotes the warp consists of two straight threads, and the woof of an exceedingly regular series of overlapping lobes. In the hackled band of *Amaurobius* the warp consists of four threads. Two of these lie in the central portion of the band; they are straight and parallel. The other threads extend, one along the middle of each lateral half of the band, and are curled. These four threads support a sheet of viscid silk, the woof. The woof has a wavy outline, but does not consist of a regular series of lobes, as in the Uloboridæ. In the hackled band of *Filistata* there are four kinds of silk: first, a double supporting line; second, the primary looped threads, third, the secondary looped threads; fourth, the woof of viscid silk.

*The Divided Eyes of Blepharocera tenuipes Walker:* WM. A. RILEY, Cornell University.

The physiology of the divided eyes of *Blepharocera tenuipes* has been discussed by Kellog, but aside from incidental mention nothing concerning their morphology has been published. The facets of the dorsal eye average forty microns in diameter, those of the lateral eye twenty-four microns. Both eyes are clothed with hairs, usually one at each facet angle, rarely two. In section the dorsal ommatidia are about three times the length of the lateral. Unlike other nematocerous diptera studied, the eyes—both dorsal and lateral—are of the pseudocone type. Among the numerous, slender, secondary pigment cells may occasionally be found a much-reduced trichogen cell. There is no special corneal hypodermis such as is present in Crustacea and Collembola, but it is represented by the primary pigment cells. The

presence of abundant pigment between the ommatidia and the position of the visual rods preclude the formation of superimposed images. There is no evidence of pigment migration dependent upon intensity of light. In the youngest pupæ studied the eye is represented by a one-layered hypodermis in which groups of enlarged sensory cells are separated by more slender cells. There is no invagination, but the groups of sensory cells become bud-like, pushing the pseudocone cells and the primary pigment cells to their distal surfaces while the secondary pigment cells become crowded into wedge-shaped masses at either end. In course of further growth the elements elongate greatly. The lateral eye differentiates more rapidly than the dorsal, a condition to be explained by the late phylogenetic appearance of the dorsal eye.

*The Nervous System and Nephridia of Dinophilus:* J. A. NELSON, Cornell University.

The nervous system exhibits an embryonic condition, consisting of a brain in close contact with the hypodermis, and a pair of lateral nerve cords, connected by transverse commissures arranged metamerically. Ganglion cells, lying within the hypodermis, accompany the lateral nerve cords, and are arranged to form five pairs of ganglia. A preoral commissure connects the circumœsophageal commissures. The nephridia number five pairs, and are arranged metamerically. Those of the posterior four pairs are simple, and similar to those of annelid larvæ, terminating blindly at their inner ends. Those of the first pair are much more complex, each exhibiting two curious canalar plexuses. The whole anatomy indicates close relationship to the annelids.

*Early Stages in the Development of the Salivary Glands in Sheep and Pig Embryos:* WM. C. THRO, Cornell University.

*Glands in Sheep Embryos.*—In an embryo 17.5 mm. long all the glands are present. The submaxillary is the most advanced, since a few side buds project from the body of the gland. The sublingual consists of a short ridge-like projection of the epithelium lining the mouth-cavity. In a 20 mm. embryo the sublingual consists of a solid cord of cells attached by its cephalic end to the epithelium lining the mouth-cavity and running caudad a short distance beneath the epithelium. In a 26 mm. embryo Wharton's duct possesses a lumen. In a 43 mm. embryo the sublingual and parotid have lumina. In an embryo 44.5 mm. long the ducts of the submaxillary and sublingual run side by side and open beneath the tip of the tongue, cephalad of the frenum.

*Glands in Pig Embryos.*—In an embryo 15 mm. long, head-breech measurement, the very earliest stages of the parotid and retrolingual glands are found, while the submaxillary is represented by a well-developed bud with enlarged extremity.

*The Development and Relations of the Columella in the Amphibia:* B. F. KINGSBURY, Cornell University.

*The Inheritance of Characteristics in Poultry:* C. B. DAVENPORT, Carnegie Institution, of Washington.

In how far are the characteristics of organisms immutable units, incapable of modification, even when pitted against each other in pairs, as occurs in hybridization of individuals having opposed characteristics? If the characteristics typically blend in the hybrid offspring, the theory of unit characters loses its main support; but if they typically do not blend, but reappear in the hybrid offspring, each in its pristine purity, then the theory of unit characters is supported and its corollary—evolution by mutation—follows. Hybridization of poultry shows that most characteristics do not blend and do reappear in subsequent hybrid progeny almost unaltered —*almost*, but not quite.

*The Egg-laying of Chironomus annularis:* JAMES G. NEEDHAM, Lake Forest, Ill.

*Chironomus annularis*, one of the larger midges of wide distribution in Europe and North America, occurs in the campus pond at Lake Forest College, where in May a number of new observations were made as to its manner of oviposition. The eggs are extruded while the female is hanging up among the leaves of the sedges at the water's edge. There occurs a preliminary flight back and forth across the water lasting fifteen to twenty minutes. This flight ends well in-shore, where the female settles and releases the egg masses upon the surface. The egg mass gradually settles beneath the surface, but remains attached to a little transparent float by a slender adhesive gelatinous thread which stretches out to a length of about six inches. The mass then drifts until this suspensory thread comes in contact with some submerged sedge leaf or other solid support, where it remains until hatched. It contains about 1,800 eggs, which hatch in about three days.

*Some Notes on the Breeding Habits of our Ithaca Anura:* A. H. WRIGHT, Cornell University.

Of the eight local anura, there have been identified the eggs of all in the field and of six in captivity. The mating embrace has been photographed with all excepting *Rana catesbiana*.

C. JUDSON HERRICK,
*Secretary*

SECTION G.

# BOTANY.

## OFFICERS OF SECTION G.

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*Vice-President and Chairman of the Section.*

D. T. MACDOUGAL, Washington, D. C.

*Secretary pro tem.*

GEO. F. ATKINSON, Ithaca, N. Y.

*Member of Council.*

D. T. MACDOUGAL.

*Sectional Committee.*

ERWIN L. SMITH, Vice-President, 1906; D. T. MACDOUGAL, Vice-President, 1907; F. E. LLOYD, Secretary, 1904–1908.
F S. EARLE, 1 year; C. E. BESSEY, 2 years; W. J. BEAL, 3 years; C. R. BARNES, 4 years; WM. TRELEASE, 5 years.

*Member of General Committee.*

J. C. ARTHUR.

*Press Secretary.*

GEO. F. ATKINSON.

## REPORT OF THE SECRETARY OF SECTION G.

In accordance with arrangements previously made the section met on June 29 for the transaction of business and the discussion of the future relations of the section to the Botanical Society of America. Professor George F. Atkinson was elected secretary *pro tempore* in the absence of Professor F. E. Lloyd.

The principal features of the meetings on the following days were the splendid excursions which had been arranged by the local committee. Adequate transportation, well-appointed lunches, and the presence of the botanists of the botanical department of Cornell University, who were familiar with the flora, made these outings a very profitable feature, and called out an attendance as large as that customarily seen at technical sessions.

On Saturday, June 30, a party of twenty-three visited the atoll moor near Chicago, eighteen miles from Ithaca. For a distance of twelve or fifteen miles on the route the glacial "dumps" or terminal moraines were visible to the party, showing in many cases the "kettles" or "pot holes" or "cat holes," as they are variously termed, many of which support characteristic moor vegetation. The atoll moor which was first visited was the site of a former large glacial pond which is now nearly filled by the growth of vegetation, there being a deep, central, small pond and an outer moat containing water at the shore of the original pond.

After lunch on the west bank of the moor Professor Atkinson gave a brief talk describing the topography of the moor and outlining the different theories which have been suggested in explanation of the peculiar topography which has been formed by the vegetation filling in. Dr. Wiegand called attention to the principal species of plant formation, pointing out the work of each in moor formation.

The party then explored the vegetation of the border along one side, which is made up of grass, sedges and herbs. Here a large number of Uredineæ were found, among which were five or six heterœcious species with the æcidial stage and the uredo stage growing on adjacent hosts, as pointed out by Dr. Arthur. The *Cassandra* formation, which covers the large part of the moor inside of the moat, was then explored. In reaching this it was necessary to cross the water in the outer moat and also a narrow elevated ridge just inside of this, which for a great distance is covered by *Spiræa salicæfolia*. Among the *Cassandra* were quantities of *Sphagnum*, and many other plants lesser in number, as *Andromeda polifolia*, *Vaccinium macrocarpon* (cranberry), etc.

From this moor the party was led to one of the smaller and deep kettles,

which contains at this season but little water. The zonal formation of the vegetation is also characteristic here: the center is a sedge and grass formation, the border an *Isoetes* formation, which at this time was partly submerged and partly on dry land. Between this and the central grass formation were partially submerged aquatic plants.

The party next drove to Malloryville Moor. On one of the banks of this moor is a bed of *Pteris aquilina* (brake) which every year presents numerous cases of apospory, though the season was a little early for good examples. This moor is a high moor. The center is occupied with *Andromeda polifolia* and scattering *Cassandra*, with a deep bed of sphagnum. Pitcher plants, orchids, etc., were observed. Upon one side (south) the *Andromeda* is each year attacked by a parasitic fungus, *Exobasidium*, which causes a regular hypertrophy of the leaves. The affected shoots are colored a bright red, and the leaves instead of being thick, narrow and with inrolled edges, are thinner, broadly elliptical and flat, taking on exactly the shape of the *Cassandra* leaves, so that but for the color it would suggest a "bud shoot" of a *Cassandra* from an *Andromeda*. The appearance of two generic types in the branches of one shoot is very striking.

On Monday, July 2, a party of thirty-four drove to Enfield Gorge, alighting at the foot of the gorge, while the carriages were taken to the head of the gorge, a little more than two miles distant. The numerous successive falls and cascades were observed, also the geological formations, but especially the vegetation. There were numerous liverworts in the wet rock walls. In one place *Preissia* and *Conocephalus* are abundant and are usually brought into zonal formation by the different moisture conditions which vary according to the surface contour of the perpendicular rock wall. At a short distance *Pellia* usually grows where there is a greater quantity of water dripping down the rock. This year there is more moisture than usual. The dripping water is so abundant that it is killing out the *Preissia* and *Conocephalus* in certain spots and the *Pellia* is coming in and overgrowing them. These features were very easily demonstrated. Higher up on the clay bank at this place *Blasia* is abundant, and on the flat rocks below *Marchantia* was found.

Near the upper end of the gorge was an abundance of the fern, *Pellæa gracilis*, on the moist rocks. The vegetation of the small alluvial plains here and there was rich in forest and shade plants which afforded an excellent opportunity for observation of "mosaics" and various ecological features.

The interest shown in a meeting in which the out-of-door features occupied so prominent a place suggests the desirability of their annual repetition, although it is by no means to be taken for granted that field excursions might always be organized under such favorable circumstances as those offered by Ithaca and the Cornell botanists.

D. T. MacDougal,
*Chairman Section G.*

SECTION H.

# Anthropology.

## OFFICERS OF SECTION H.

*Vice-President and Chairman of the Section.*

HUGO MÜNSTERBERG, Cambridge, Mass.

*Secretary.*

GEO. H. PEPPER, New York, N. Y.

*Member of Council.*

ALCÉE FORTIER.

*Sectional Committee.*

HUGO MÜNSTERBERG, Vice-President, 1906; GEO. H. PEPPER, Secretary, 1904–1908.
W J MCGEE, 1 year; Miss ALICE C. FLETCHER, 2 years; GEO. GRANT MACCURDY, 3 years; ALES HRDLICKA, 4 years; FRANZ BOAS, 5 years.

*Member of General Committee.*

Miss CORNELIA HORSFORD.

*Press Secretary.*

GEO. H. PEPPER.

[No meeting of Section H was held and no papers presented before this section at the Ithaca meeting.]

SECTION I.

# Social and Economic Science.

## OFFICERS OF SECTION I.

*Vice-President and Chairman of the Section.*

CHARLES A. CONANT, New York.

*Secretary.*

JOHN FRANKLIN CROWELL, 44 Broad St., New York, N. Y.

*Member of Council.*

MARCUS BENJAMIN.

*Sectional Committee.*

IRVING FISHER, Vice-President, 1906; CHARLES A. CONANT, Vice-President, 1907; JOHN FRANKLIN CROWELL, Secretary, 1904–1908. B. E. FERNOW, 1 year; FRANK R. RUTTER, 2 years; WM. R. LAZENBY, 3 years; E. L. CORTHELL, 4 years; CARROLL D. WRIGHT, 5 years.

*Member of General Committee.*

LE GRAND POWERS.

*Press Secretary.*

JOHN FRANKLIN CROWELL.

ADDRESS

BY

# IRVING FISHER,

VICE-PRESIDENT AND CHAIRMAN OF SECTION I FOR 1906.

## *ECONOMICS AS A SCIENCE.*

That economic and social studies should be carried on with the scientific method and spirit is not likely to be denied by anyone here present. And yet there are persons who would have us believe that these important fields of investigation are by nature incapable of such a treatment. Even among economic students we find many writers of the type of Cliffe Leslie, who definitely disclaim that economics is a science, and class it rather as a branch of history. There has always been more or less hesitation as to the place economic studies should occupy as between the historical and scientific poles. The tendency to lean toward the historical side is indicated by the fact that the American Economic Association has regularly met in conjunction with the American Historical Association, while the tendency toward the scientific side is indicated by the fact that this section exists as a branch of the American Association for the Advancement of Science.

Those who maintain that economics is not and never can be a true science base their contention on the fact that social phenomena are not constant, "like," they say, "the phenomena of astronomy or physics," but differ widely at different times and under different circumstances. They point out that the determination of prices under modern free competition is quite different from their determination under the medieval

system of custom and status; that the remuneration of labor depends on what are the historical and legal institutions with respect to slavery, labor legislation, etc.; that the economic phenomena of to-day are not comparable with those of the times of the Greeks and Romans, nor are the phenomena in America comparable with those in Russia.

To one who is familiar with the spirit of science, however, these variations, so far from being objections, are really confirmations of the theory that economics is a science. For in all science it is fundamentally true that phenomena will "differ according to circumstances," and the office of the scientist is simply and solely to find out under what circumstances one set of phenomena will occur, and under what circumstances another set will occur. We could hardly claim that hydrostatics is not a science for the reason that, in a mountain lake, water is found to be stationary and at a level, whereas at Niagara it is found to be in motion and passing from one level to another; that whereas the water in a mill-race passes in a downward direction, the water which we draw in our houses moves through the pipes upward; that whereas, by means of a syphon, water may be induced to flow out of a receptacle, it will, in an ordinary tub, remain inert. The whole science of hydrostatics has developed as a consequence of the persistent effort to unravel these puzzles, and to-day we know not only that under different circumstances water will act in different ways, but we can formulate what are the precise conditions under which it will act in each separate manner.

In economic study we should in like manner apply ourselves to discover what conditions make the difference in the phenomena between modern and ancient or eastern and western civilizations, rather than content ourselves with the truism that they do differ. Much of the field has in fact already been covered. It is known, for instance, that under conditions of free contract and competition, the price of an article will be determined by the intersection of its supply and demand curves, and that, on the other hand, if the régime be one of monopoly, the price will be determined on the principle of "what the traffic will bear," in the manner so admirably shown by Cournot. In these cases the results are not absolute and unconditional,

but depend on specified hypotheses. In this respect they are exactly similar to any other scientific result. The formula of science, as Newcomb points out, is always conditional—if *A* is true, then *B* is true. The formula of history, on the other hand, is unconditional—simply *B* is true.

If economics is a science, its truths must be conditional. Thus, the incidence of a tax on ground rent will lower the value of land, *provided* there are no counteracting causes. This does not assert that actually, after such a tax, the value of the land will fall, for in the meantime some opposing cause may have intervened, such as the discovery of an oil-well. Again, an increase of the quantity of circulating medium will raise prices proportionately, provided the velocity of circulation and the volume of business transactions remain the same. This "quantity theory" does not assert that prices *do* rise after every increase in the quantity of money, and those who thus interpret it are guilty of the confusion already noted between conditional and unconditional truth—in other words, between a scientific law and a historical fact.

The confusion between historical and scientific truth is very common among economists, especially in the German historical school. While Roscher and his followers verbally classify economics as a science, they leave no place for economic *theory*. Curiously enough, they imagine that by confining themselves to historical generalizations they are following the inductive method of Bacon. A closer study of Bacon's work would have revealed to them that true science does not consist in the mere grouping of historical phenomena. In fact, Bacon makes a distinction between what he calls the popular and the inductive method, or what may be preferably called, following the example of John Rae, the *systematic* and the *scientific*. The two are commonly confused, but are entirely distinct. "System" consists in classifying phenomena; "science" consists in discovering the laws to which they conform. System explains phenomena by means of what is common and familiar; science explains them by what is simple, however recondite. System is exemplified in such descriptive studies as grammar, descriptive geography and history; science is exemplified by such analytical studies as mathematics, physics, and latterly, biology.

The classifier or system-maker is content with generalization of facts. These express the *usual* order of events: for instance, that the sun rises once a day. They do not express the reason or principle. The difference between system and science is the difference between a general fact and a necessary truth, between *rules* and *laws*. Exceptions to rules do not destroy them as rules; in fact, we say "the exception *proves* the rule." This, however, is not true of laws. A "law" which has an exception is no law at all.

Many studies which are now scientific had their origin in what was originally systematic. The predecessors of the modern physicists classified bodies into "light" and "heavy." Iron, they maintained, is heavy and therefore falls; fire is not heavy, and therefore rises. How different is this obsolete method of treating the subject from our modern analytic notion of gravity, or rate of increase of velocity, by means of which are explained both the falling of iron and the rising of "fire."

Similarly, the prototype of biology was "natural history," and consisted chiefly in the mere classification of animals and plants into species, genera, etc. Modern biology has supplanted such elaborate classification by introducing, through Darwin, the analytical ideas of heredity, variation and selection, and in this way the descriptive study of natural history has been converted into the true science of biology.

The same evolution which has been outlined in physical and biological science is doubtless taking place in economic science. Yet it must be confessed that few have yet mastered the distinction between a general fact and a scientific law. When we hear it stated as fundamental in political economy that skilled labor is better paid than unskilled, it is clear that this is merely a general rule and not a necessary law. The single fact that certain seamstresses, though skilled, are ill-paid, is sufficient to disprove the statement as a necessary law, though it does not affect it as a general fact.

The historical school justly complains of the superficial character of the theories which have been sometimes offered. This objection holds, however, not against theory as such, but against *false* theories; and herein lies the virtue of Bacon's method. The inductive method, by which any theory of phe-

nomena must be checked by reference to actual historical fact, thus forms the means of distinguishing between truth and falsity. Rejecting false theories is quite different from rejecting all theories. What is needed now in political economy is to rid ourselves of the false and superficial theories, on the one hand, which have been constructed *a priori* and irrespective of facts; and, on the other hand, to release ourselves from the cheap empiricism of the historical school, who interpret their task as merely one of generalizing phenomena without analyzing them. In the words of the great philosopher, Hume, "Our speculations can scarce ever be too fine, provided they be just."

Science is one. The logic for economic science should be the logic for all science—a combination of induction and deduction. Facts are at once the test and the material of science, but laws are its ultimate goal. Laws are not facts, but the relations between facts. Newton's first law of motion, that a body tends to move uniformly in a straight line, is not a fact, nor it it a general expression of facts. Probably no particle in the universe has ever moved exactly in a straight line or with uniform velocity for so much as a single second. Yet it would be an error to conclude that Newton's law is unreal and untrue in actual nature. The law has an "if" in it—"*if* a body were acted on by no force, or by perfectly balanced forces, its motion *would* be uniform in both rate and direction." Withdrawn thus from actual events, Newton's law seems to the non-scientific mind to lose all objective truth. This again is an error. Newton's law is absolutely true to nature. The fact that it is conditional does not make it arbitrary. We are not free to replace it by the medieval opinion, viz., "If a body is let alone it will gradually spend its force and slacken its speed." This formulation, unlike Newton's law, would not stand the test of facts. A valid law is true at all times and places, in the sense that should the particular conditions arise, the prescribed result would follow, but not in the sense that the particular conditions must needs ever arise.

When the relations between scientific and historical truth are more fully realized, we may expect economic studies to make more rapid strides than have hitherto been possible.

We shall recognize the twofold nature of most practical economic problems, such as the present problems of trades-unions, insurance, railroad-rate regulation and the tariff. These problems require first of all the study of historical facts, and secondly, the discovery of the relations to which these facts conform. When these two studies are complete we are prepared to take a third and final step, *prediction*. It is sometimes said that the ability to predict is the final test of science. But it is not a test of science only. Successful prediction requires two conditions: one is a knowledge of science—of what will happen under given circumstances; and the other, equally essential, is a knowledge of history—of the particular circumstances of the present moment, out of which the future, to be predicted, will grow. Failures of prediction are due to the lack of either of these two essential conditions.

An example of a failure of prediction due to imperfect knowledge of facts is found in the case of the closure of the Indian mints to silver in 1893. It was expected that the value of the silver rupee would be maintained at 16 pence. But no account was taken of the large coined hoards of silver among the natives. After these had been put into circulation the price of the rupee did eventually rise to 16 pence and has remained there ever since. In this case the failure of prediction at first was due, not to any defect in monetary *science*, but to ignorance of Indian *history*.

Usually, however, failures in economic prediction are due to the lack of scientific rather than of historical knowledge. In the Civil War, when there was a premium on gold, the scientific explanation of which was really simple, the public attributed the premium to the machinations of speculators. Accordingly, Congress was induced to close the Gold Exchange, whereupon, to the consternation of the framers of this foolish prohibition, the premium on gold soared higher than ever. The result was a hasty and shamefaced repeal.

Experience of this kind is too common in economic legislation. It serves as a warning that we should know something of economic science before venturing to tamper with economic conditions. The men who need this warning most of all are those who despise all "theories" and call themselves "practi-

cal." It is they who legislate a measure one day and have to repeal it the next. A *truly* practical man can predict how a measure will work, and his power so to do requires not only what is called "practical" but also what is called "theoretical" knowledge; a knowledge, in short, not only of *history* but of *science*.

## REPORT OF THE SECRETARY OF SECTION I.

The address of the retiring vice-president, Professor Fisher, on "Economic Science,"* was followed by an address of welcome by Professor Frank A. Fetter, ex-secretary of the American Economic Association, in which the work of the section was commended for its services in emphasizing the scientific method in economics in contrast with the conception which gave most attention to theoretical discipline.

The discussion of Professor Norton's paper (see below) by Dr. W. H. Welch, of Johns Hopkins, and Dr. A. C. Abbott, of the Philadelphia Board of Health, added materially to the value of this session. Dr. George W. Kober, of Washington, and Fred. L. Hoffman, of Newark, sent communications on this paper, the latter especially criticizing the proposals relating to federal control of medical institutions.

*Economic Advisability of a National Department of Health:* Professor J. PEASE NORTON, Yale University.

The salvation of the civilization and the race lies in the hands of exceptional men. The hope of the race inheres in their efficient organization for action. Organization consists in compelling voluntarily or involuntarily each individual to do that thing within his capability which has greatest value for society. To do otherwise is a great waste. To permit great wastes to go unchecked is more than a suicidal policy; for an evil more heinous than race suicide is race homicide.

There are four great wastes to-day, the more lamentable because they are unnecessary. They are preventable death, preventable sickness, preventable conditions of low physical and mental efficiency, and preventable ignorance. The magnitude of these wastes is testified to by experts competent to judge. They play their part in a cruel devastating destruction that is almost incredible to the human mind.

The economic reasons for establishing a national department of health are five: (1) To enable society to progress more rapidly under the law of increasing returns through increasing the per cent. of exceptional men of each degree (many of whom are now lost through preventable accidents), in addition to increasing the total population. (2) To lessen the burden of the unproductive years on the productive years by increasing the average age at death. (3) To ddcrease the burden of death on the productive years by increasing the age at death. If the expenses of illness and death are $300 and the average age at death is forty years, the average death expenses

* See SCIENCE, August 31, 1906.

average $15 on the twenty productive years. Could the average age be increased to 50 years, the burden falls to $10 or a decrease of fifty per cent. For 80,000,000 of people, the saving of $1.50 per year of life would be equivalent to $120,000,000 per annum. (4) To lessen the economic burden of sickness. Assuming Newholme's figure of nine days average illness per annum, approximately 2,000,000 years of life are lost per annum. Estimating wages at $1 per day, and all other expenses $1 per day, $1,444,000,000 loss per annum is registered by this item. Could the days of illness be cut down one-third nearly $500,000,000 would be saved. (5) Higgins has estimated that six hundred millions are now spent on criminality in the United States. If the criminality is largely the product of social environment, such as over-crowding, alcoholism, etc., measures which would decrease this only fractionally are worthy of consideration. A decrease of 16⅔ per cent. would result in savings of $100,000,000 per annum.

For the last four estimates, the total savings range between $1,800,000,00 and $4,000,000,000 per annum. In addition to the positive gain, in addition to the savings above, there exists a vast amount of misery and sorrow which would be lessened, but may not be measured by statistics.

*How Shall the Destructive Tendencies of Modern Life be met by the Individual?* Dr. RICHARD COLE NEWTON, Montclair, N. J.

First of all a physical education is needed to develop, strengthen and preserve the body. In spite of mechanical and scientific advance, we are far behind in respect to the rules of simple and healthful living. A systematic study of diet, use of narcotics, employment of exercises as they apply to 10,000 people for ten years, would settle many fundamental questions which nothing short of government could successfully undertake to solve. A national bureau of health should be formed to undertake such studies and experiments as are necessary to make these inquiries. This bureau should pass on every new remedy and every proposed system of treatment, so that the humblest citizen might know that he will not injure himself in using such remedies or systems of treatment. By positive directions and training the Japanese have made their armies invincible. We must profit by their example if we would maintain our national life and our racial preeminence.

*Limitation of Great Fortunes:* Professor JAMES WALTER CROOK, Amherst College, Mass.

The problems connected with the amassing of enormous fortunes have been given a special importance by President Roosevelt's Washington address, on April 14. The remedy by him proposed was a progressive tax so framed as to prevent giving or bequeathing fortunes, over a given amount, the tax to be imposed by the federal government.

Unlimited opportunity to accumulate fortunes has a selective value by attracting a large share of the best talent into business. A change

would affect commercial activity as a pursuit. It would create a new source of federal income and greatly modify the distribution of wealth in the community.

We must remember that the wealthy in large measure manage their wealth for society. Before radical action we should consider whether the growth of large fortunes is due to temporary or permanent causes.

The causes of great fortunes are, as a rule: (1) Underground resources (mining, oil, etc); (2) development of transportation facilities; (3) combination of corporate enterprises; (4) increase in land values; (5) speculation in corporate securities; (6) monopoly. All except the second and the sixth are still open fields for the fortune maker.

Possibly something, not much, may be expected as a remedy from seeking an honorable family name, from public service, but the remedy is too remote.

Of the three methods proposed: (1) An arbitrary limit to accumulation, (2) progressive income tax, and (3) progressive inheritance tax, the first is arbitrary, the second no less acceptable, and the third is good for raising revenue but doubtful as a means of repressing accumulations.

A tax heavy enough to accomplish the purpose would raise problems of fiscal administration of a perplexing character, both in the collection and use of the funds. Economically, such a tax would repress industrial activity, financially it might cause extravagance in governmental expenditure and disturbance of the money market by its collection.

On the subject of agriculture the introductory talk of Professor L. H. Bailey, of Cornell, on the "Problems of Agriculture," and the paper by Professor G. N. Lauman, on "Rural Conditions and Problems in Europe, were timely and full of suggestion in the service of American experience.

Professor Bailey said: The farm is going to be laid out by the rural architect with regard to good taste. We shall begin with the highways and take down the advertising signs among the first. Sanitation will play a large part. Even now many of our best dairy stables are more truly sanitary than the majority of homes in city or country. The rural home must solve its servant problem (1) by simplifying its food preparation, and (2) by reduction of labor with mechanical appliances.

*Causes and Consequences of the Past Ten Years of Agricultural Prosperity in the United States:* GEORGE K. HOLMES, U. S. Department of Agriculture.

The prosperity of farmers, which has been preeminently in evidence during the last half-dozen years, must be and is logically reflected in the higher capitalization of their lands, and in better and additional buildings and other improvements. It has been ascertained by the U. S. Department of Agriculture that the farm real estate of the United States increased 33.5 per cent. in value during the five years following the census of 1900, or an amount that averaged $100,000,000 a month and equaled $6,000,000,000.

There has been a cessation in recent years of the longtime tendency to overproduction; there is no more cheap cultivable land of nation, state and railroad to be robbed of its fertility for cheap production. The agricultural population is becoming a smaller fraction of total inhabitants, and there is a nearer approach to equilibrium between agricultural production and consumption, helped by enormous exports of cotton, grain and meat. In the meantime, immigration, which had long poured its hordes upon the farms, has changed in character and been diverted to the cities, to consume instead of multiply the products of the farm. Besides, the consumption per capita of some things seems to have increased—of wheat, meat and its products, vegetables, fruit, poultry and eggs.

These are among the chief causes that are making agricultural consumption tend to push agricultural production, with the result that prices have risen and farming operations have become more profitable.

The greatest economic gain that the farmer has made, apart from higher prices, is the freedom to shift from one crop to another, the most conspicuous illustration being cotton. Now that the planter is not generally working against a crop lien bearing 40 per cent. interest and profit to secure advances for living and production, and has no creditor who will lend on no security but cotton, he is in a position to raise cotton or some other product, as he pleases, and there will never be an excessive crop of cotton again, unless by chance for one year, as in 1903.

Among other results of prosperity are the ability of the farmer to borrow at a low rate of interest, his enormous accumulations, deposits in banks, and investments, the cancellation of old farm mortgages, and his ability to hold his crop after harvest until the price is satisfactory to him, in place of dumping it upon the market as he formerly did to pay debts and expenses. The farmer now has an impregnable economic position.

*Economic Geography:* Dr. J. RUSSELL SMITH, Wharton School. University of Pennsylvania.

Economic geography is a study of the world in which we live as a place in which to make a living. Another way of putting it is that it is the description of lands in terms of human usefulness. This phase of geography does not permit itself to be carried off into speculation of purely scientific interest unless there is also an economic aspect. It is held down by that qualification of human interest—usefulness to man.

Almost every industry and every form of human activity is controlled by the physical conditions of the land in which the people live. The understanding of these relations is economic geography, and it is one of the shortcomings of our educational system that this study has not received greater attention.

Economic geography needs to go into higher education in as thorough a way as has been the case with history. It is useful not only to other sciences but to the direct preparation of the individual for citizenship and business.

The concept and treatment of history have been rapidly changing because of the growing recognition of the part that economic conditions have had in shaping human affairs. The understanding of the past and the present are alike in their requirements. The science of economics, like history, requires for its understanding the fundamental facts of economic geography. Economic geography gives the economic facts that are requisite to an understanding of economic theory. Many of the problems of political science also grow out of geographical conditions.

Private industry and investment also depend closely upon the information given by economic geography. Twenty years ago there was a great rush of emigrants into western Kansas. They were unfamiliar with the economic geography of the region and a quarter of a million of them attempted to make farm homes where it was impossible to do so. They were driven out bankrupt after years of labor, and eastern mortgage holders also lost millions. Economic geography is quite as important to the financier as to the representative of industry or government.

On the general theme of municipal ownership four papers were presented. That by Charles W. Tooke (Syracuse, N.Y.) dealt with legal and financial phases of the problem. The discussion was opened by Charles Whitney Baker of the *Engineering News*, New York City, who said:

The "public utilities" in cities at the present day are absolute necessities; hence their control or operation by the public authorities is a far more vital question than it was twenty years or even ten years ago.

There have been three important changes in the public point of view of the municipal ownership question: First, the enemies as well as the friends of municipal ownership are now agreed that public utilities, if not owned by the city, must be operated under strict franchises, providing for good service and regulation of rates and limited in duration.

Second, all are agreed that "public utilities" are natural monopolies and that attempts to create competition in the gas, water or electric supply, are in the long run injurious, both to the stockholders and to the public, and hence should not be permitted.

Third, the recent disclosures of inefficiency, corruption and wholesale graft in some of the private corporations which the public has been accustomed to regard as models of good business management, have enabled people to make a fairer comparison between municipal work and private work. Public utilities in most cities are and must be operated by large corporations, unless the cities themselves take charge. In these corporations, there is and will inevitably be more or less red tape, inefficiency, graft and corruption. It probably still remains true that this corporate management will generally be more efficient than city management, but the difference is far from being as great as has usually been supposed.

*Public Ownership and the Wage-Earners:* H. T. NEWCOMB, Washington, D. C.

In its efforts to convert municipal, state and national governments

to particular portions of its socialistic program the persistent propaganda of public ownership, whose tireless activities so visibly pervade current American politics, usually demands the support of wage-earners upon the ground that the employees of public enterprises will be more favorably treated than those of private enterprises in the same field. It is claimed that public ownership means higher wages; shorter hours of labor, and, generally, better conditions of employment.

Experience proves not only that the government is not the best employer, but that it is not even a fair employer. Nor is this all. When government engages in industry on a large scale the condition of its employees naturally and inevitably degenerates to that of slavery.

Government does not advance wages with the increased cost of living.

Democracy is an arbitrary employer. Public employees must not seek to better their condition, on penalty of discharge, according to President Roosevelt's order of January 31, 1902.

Compulsory labor in New Zealand (Parsons, "Story of New Zealand," p. 179 *et seq.*) gives no hope to labor for freedom under government employment.

The public employer has neither the knowledge of labor conditions nor the incentive to efficiency which springs from the demand for pecuniary success. As truly as republics are ungrateful, the majority is sure to prove harsh as a task-master, and grudging in yielding compensation to its servants. Its enthusiasms are usually, not always, towards generosity, but they are changing, remittant and unreliable, while its sterner morality produces an ideal of justice that inspires the niggardly legislator while he crushes, in the ostensible interest of the taxpayer, every proposal to deal fairly and, therefore, wisely, with the problems arising out of the public employment of labor. More than this, democracy, or the majority, through which it operates, is intolerant of disagreement with its principles, relentless in beating down opposition to its policies, merciless to the minority which persists in impeding the execution of its will. What could such an employer be, in dealing with labor on a large scale, save a harsh task-master? What could it naturally become save a driver of shackled slaves? Where is the clear-headed and independent wage-earner who will consciously invoke such tyranny?

*Fallacies of Municipal Ownership:* ALLEN RIPLEY FOOTE, Secretary State Chamber of Commerce, Columbus, Ohio.

The most beneficient service a government can render the people is to correctly regulate, not to own and operate, public service utilities. Every gain made in reducing prices for services charged to the people by eliminating the political elements of the costs of ownership and operation paid by corporations, can be eliminated by placing corporations under a correct system of regulation, and granting them, without charge, every privilege enjoyed, without payment, by the municipal corporation.

Politicians now take advantage of corporate mistakes to make promises of better service. They make a show of keeping their promises to the people, by the simple process of not charging into the account numerous items, all of which are paid by corporations and must be covered by prices they charge for services rendered. The apparent gains sometimes shown by municipal ownership advocates in the department of economic costs, on close analysis and inspection are invariably found to be the products of political book-keeping, and an unsound financial policy. These include the payment of the interest account on bonds out of the tax-payers' money and charged to general expense, instead of to the operating expenses of the utility; no insurance, with losses by fire to be paid out similarly; no account taken of depreciation.

Economic gains are thus shown, but not made. Such gains must be earned; they cannot be created by a flat resolution. Instead of making savings for the people, municipal ownership has resulted in hampering, restricting and deadening all enterprises and improvement in the industries it has absorbed, and in placing heavy burdens upon the tax-payers.

Correct regulation would require all corporation accounts to be kept in the form prescribed by the state for the information of the people. There would be an end of watered stock; wars between competing corporations would cease; operating costs would not be inflated by charges for franchises and property taxes; prices charged for services would be true economic prices.

*The Corporate and the Individual Conscience:* CORA AGNES BENNESON, LL. B., Cambridge, Mass.

Within the last decade great changes have taken place in business management. From individuals it has passed to corporations, composed of individuals, to be sure, but they must now consider corporate instead of personal interests; they have, or should have, a corporate conscience.

Granted, that although a corporation proverbially has no soul, it has a corporate conscience. Who is responsible for that conscience—the stockholders, the directors, or the state?

On measures involving public welfare, the state conscience should be on the alert. If a corporation corners a necessary commodity, like wheat or coal, or unduly cheapens labor, it is dangerous to the republic and the state should take away its charter. State laws should be passed protecting minority stockholders.

The directors are responsible for the corporate conscience, when they resort to double-dealing, as, for instance, privately giving lower railroad rates to certain corporations than to individuals, or exploiting the corporation for private ends. The remedy lies with the stockholders to put such out of office. Stockholders are responsible for the corporate conscience when they permit corporate measures they would not personally sanction.

Few stockholders attend annual meetings. If they absent themselves, what right have they to complain that the directors are self-elected and

a small number or even one gains control? Attendance gives opportunity to ask questions; the more searching these are, the more welcome are they to directors who have nothing to conceal and who have kept the corporate conscience clean.

*The Public Bath System of Brooklyn:* WILLIAM H. HALE, Brooklyn, N. Y.

A system of free baths is a most important and beneficent exercise of municipal ownership, conducing as it does to public health and ultimately to improvement of public morals.

The floating baths have long been in use along the river front during the summer season; three of these dating back nearly or quite thirty years are still in commission; two more were built in 1897, and the five are now open to the public. It is estimated that 1,500,000 people used these baths last summer.

The system of interior baths open the year around is very recent. Six have been opened thus far.

These baths provide shower baths, with hot and cold water, free to all. Soap is provided at a cent a cake and use of towels for a cent. Tubs in private rooms, with soap and use of towel, cost five cents.

Great care is taken to keep the bath-houses well cleaned, and this is so well done that many of our good citizens use the public baths, and many persons regularly come from New York to use them.

Receipts for soap, use of towels and use of tubs in 1905 were $4,446.75 The estimated attendance during 1905 was 6,000 a day.

The cost per capita of each bath for the Montrose Avenue bath for April 1906, was 3.42 cents. The number of bathers for this month was reported as 47,956, and the cost of operation of that bath above receipts for that month was estimated at $1,594.01. This does not include the cost of the water used nor any estimate to cover rent for the building, but merely operating expenses.

And it is indeed doubtful whether public funds can in any way be better expended than in the cleansing of the people by these baths, in promoting health and comfort, and in its generally ameliorating effect. It is the testimony of the attendant in charge of the bath which we have just been discussing that it has a distinctly perceptible effect not only in improving the health, but also in elevating the moral tone of the community in that immediate neighborhood.

*Regulation of Freight Rates:* N. T. BACON, Peace Dale, R. I.

The railroads legitimately object to freight charges based on mileage only, that in many cases, and especially for short distances, haulage only represents a minor part of the cost to them, being of less importance than switching, and the use of terminals and rolling stock. To meet these objections rates are proposed based on three subdivisions of the charge:

1. Terminal charges for switching and use of terminal facilities. For

this all stations should be graded, according to annual freight receipts, into say six classes, terminal charges to be uniform for each grade of stations for the different services rendered at each end.

2. Use of rolling stock.

3. Haulage.

All these should differ for the different classes of freight, but all rates and gradings should be published, and no modification allowed without publication a month in advance. Charges should be only for services rendered, so that in case of concerns owning their own sidings and doing their own switching, terminal charges would be eliminated for that terminal, but not at the other unless the freight received such treatment at both ends. Similarly no charges should be made for rolling stock against firms providing their own cars, except that where they are returned empty a suitable published rate should be made for this. These are the legitimate advantages of wealth, but no illegitimate advantages such as exclusive contracts should be tolerated. Those already existing are probably *ultra vires* for common carriers and therefore void.

Freight classification should be left to periodical conventions of general freight agents. It is too complicated for any other treatment.

Finally, the railroads should be liable for demurrage for unreasonable delays, on a basis similar to that on which they charge demurrage for delay in unloading. Some allowance should be made for extraordinary demands; bus favoritism should be drastically punishable, and the president or directors of a railroad should be personally responsible for the shortcomings of subordinates, without exonerating these. Moreover, those finally responsible should be under heavy bonds and not at liberty to avoid suit by taking refuge abroad. Our laws should be altered, to allow an action *in rem* instead of *in personam* in the case of any fugitive from justice who does not return on publication of a summons. There are few greater scandals than those of wealthy men abroad defying our laws while they depend on them for the enjoyment of the income of their property.

*The Problem of Railroad Taxation:* HERBERT N. EDWARDS, Yale University.

The modern industrial corporation has found its chief field of operation in transportation, which is the life of industrial development. In the United States, methods of assessment and collection of taxes on these properties are so varied as to be confusing. But in principle there is more uniformity. Forty-seven out of fifty states and territories tax their railroads on the basis of physical valuation. The general property tax still obtains nearly everywhere, but by methods differing from that used in taxing individual property. The method in most common use is the state board of assessment and collection. The average value per mile is the valuation basis to which any given rate is applied. But valuation is in some cases not that of use and personal property but of the stocks and bonds (Delaware, Pennsylvania, Massachusetts, New York) supplemented by gross receipts tax.

Railway taxes are now the chief source of state revenue in many cases, leaving the general property tax to local divisions. In Michigan the basis is the sum of values of the tangible and intangible property. Plehn advocates the value of their securities as the best basis and Seligman the taxation of net receipts. The states now derive $60,000,000 revenue from this source. Their methods are, however, inadequate and some form of federal control is needed for the sake of more harmonious methods.

*What may Accounting teach Economics?* FREDERICK A. CLEVELAND, New York.

To the economic dogmatist and abstract reasoner who conceives economics as composed of a set of specific doctrines as expounded by the physiocrats, the Malthusians or the Marxians, or as embraced in a congeries of concepts known as the abstinence theory of capital, the marginal theory of rent, the residual theory of labor, the quantity theory of money and the utility theory of value—to these accounting can teach nothing.

On this conception of economics, after a century of research and discussion, Professor Hollander holds that we have not as yet developed any scientific conception of industrial society. Many others agree with him. Economics as a branch of science is rather concerned with *the group activities of man toward individual and social gain.* The point of view is that (1) of economic factors, (2) of economic relations (*a*) to the material world and (*b*) to institutions both social and economic, and (3) the forms of economic income, including private and public incomes.

Already considerable progress has been made in this direction by others than economists, especially by the student of history and public law. Scientific economics considers data as related to (1) organization, (2) problems of administration, and (3) methods and technique. We must lay aside dogma and classify data to get an intelligent grasp of affairs.

Accountancy is to scientific economics what the clinic is to medicine. The examination made by the professional accountant is for purposes of prescription. A record of the diagnosis, of the prescription, of the remedial result, and of the history of the performance of normal physiological functions recorded in the accounts, may be taken as the data upon which broad scientific generalization may be based; this broad generalization should be made by the conomist.

*Structure of Cities:* RICHARD M. HURD, President, Lawyers' Mortgage Company, New York.

Cities grow and conform to economic law. The point of origin is that of contact with the outer world. In its organization from 40 to 70 per cent. of the area is used for streets, the balance is devoted to three uses: business, residences and public buildings. The distribution of business utilities is purely economic, land going to the highest bidder. Residence areas are based on social considerations. Growth is axial or central—around centers or around the circumference.

Central growth has two main aspects: first, general growth in all directions from the point of origin and second, local growth around subcenters within the city, such as transportation termini, public buildings, exchanges, factories and hotels. As a city grows, the centralizing influence of public buildings steadily diminishes while its exchanges assume increasing importance, these varying in character according to the leading business transacted in the city. Normal growth consists of the gradual aggregation of buildings of the same character due to the gregariousness of mankind and the saving in time from the close juxtaposition of buildings. Continuity is a vital feature of all growth, whether central or axial, every break causing a weakness in the structure similar to the loss of a link in a chain. An internal movement which constantly goes on is the gathering together of similar forms of business into special districts.

There are three main causes of changes in a city's structure: increase of population, increase of wealth, and new transportation facilities. Increase of population without increase of wealth would normally tend only to a gradual extension of buildings of the existing character over a larger area. Increase of wealth, however, causes continual rebuilding within the city, old-fashioned shops, dingy offices and plain residences being supplanted by buildings of a new standard of magnificence. New and improved methods of transportation draw residences beyond the city's limits, concentrate business in higher buildings at the center and establish new axes of travel as additional vertebræ for the city. More and more in the life of great cities is improved transit of importance, the tendency being for traffic to mass at intersecting points with inferior utilities in the quiet side streets.

*Insurance Problems relating to the Management of Assets and Legal Regulation of Investments:* Dr. LESTER W. ZARTMAN, Yale University, (To be published elsewhere.)

The New York insurance investigation revealed the dangers and abuses in the management of insurance assets. As a result stricter legal regulation has become necessary. The evils of insurance fund management are of three classes: (1) Officers and trustees made personal profit out of the company's funds; or (2) they took no interest in the disposition of the funds, and (3) the policy-holders to whom the funds belong exercised no control over their property.

Stricter limitation of the investing powers of officers and trustees has not proved an adequate reform. It has rather produced abuses, such as collateral loans and trust company deposits, both of which should be given up.

The vulnerable point in insurance is the making of personal profits by officers and trustees. Making this a penal offense would tend to divorce insurance management from other lines of business. Stock insurance companies should be forbidden, because of the danger of stock control, and

real mutuality secured. Abolish the proxy system and provide voting of policy-holders by mail for boards of managers are in the right direction. More reliance should be placed on the election of responsible directors than in strict legal regulation.

*Mathematics and Formal Discipline:* JOSEPH V. COLLINS, State Normal School, Stevens Point, Wis.

In the training of the reasoning powers the service of that faculty in social and economic science is to be considered. Professor Lewis (Dartmouth) in his study of formal discipline by tests in geometry and practical reasoning (*School Review*, April, 1905) shows that a relationship exists but does not prove the faculty theory true. Tables prepared by the author of the present paper show that what a student does in any subject depends more on his mental equipment and native environment than on the particular matter considered.

Mathematics gives a training *sui generis*. In arithmetic the problems correlate at many points with the actual affairs of life. Speaking broadly, though, the most important effects of the mathematical training are abilities of quite general application: as, holding a number of particulars in the mind at one time, training in sustained reasoning, habit of overcoming difficulties, recognizing the universality of the application of correctly stated laws, perceiving the need of care to secure the accuracy of results required, and so on. These powers have identity of qualities with multitudes of activities the individual finds himself engaged in in after life. They thus furnish hooks on which to hang new experiences and conquer new problems. In these ways perhaps more than in any others mathematics justifies its place in the course.

The following papers were read by title or in abstract:

*Conditions and Needs of Southern Agriculture:* Professor ANDREW M. SOULE, Blacksburg, Va.

*Labor Conditions in Southern Farming:* Professor F. W. MASSEY, Raleigh, N. C.

*Value of an Organized Working Force in Industry:* President E. L. BLACKSHEAR, Prairie View, Texas.

*Restriction of Telegraph Development Under Monopoly Control:* ROMYN HITCHCOCK, New York.

J. FRANKLIN CROWELL,
*Secretary.*

SECTION K.

# Physiology and Experimental Medicine.

## OFFICERS OF SECTION K.

*Vice-President and Chairman of the Section.*

SIMON FLEXNER.

*Secretary.*

WM. J. GIES, Columbia University, New York, N. Y.

*Member of Council.*

ALEXANDER C. ABBOTT.

*Sectional Committee.*

SIMON FLEXNER, Vice-President, 1906; WM. J. GIES, Secretary, 1905–'08. FRANK BAKER, 1 year; C. S. MINOT, 2 years; J. MCK. CATTELL, 3 years; LUDVIG HEKTOEN, 4 years; GRAHAM LUSK, 5 years.

*Member of General Committee.*

JAMES CARROLL.

*Press Secretary.*

WM. J. GIES.

[No meeting of Section K was held and no papers presented at the Ithaca meeting.]

# EXECUTIVE PROCEEDINGS.

# EXECUTIVE PROCEEDINGS.

## REPORT OF THE GENERAL SECRETARY.

The fifty-sixth meeting of the American Association for the Advancement of Science was held at Ithaca, New York, June 28–July 3, 1906. This meeting was peculiar in being an extra meeting in the summer, the winter meeting at New Orleans having been held only six months before, and a winter meeting being planned for New York six months later. As a consequence of the fact that it was an extra meeting, there were no presidential addresses, no election of officers, except to fill vacancies, and there was but little action of any kind taken by the council.

The registered atendance of the association members was 232, and 94 members of the American Chemical Society were known to be present who were not registered as members of the association, making a clearly ascertained total attendance of 326. Other information, derived from the registration of four affiliated societies, indicates that the total attendance was about 400. As to attendance, the meeting was intermediate between the two meetings next preceding, namely, at New Orleans and at Philadelphia.

The following table shows the registered attendance by sections, and the affiliated societies which met at Ithaca:

Section A, 1. (No meeting of section was held.)

Section B, 50. American Physical Society.

Section C, 45. American Chemical Society and the New York Chapter of the Society for Chemical Industry.

Section D, 23. Society for the Promotion of Engineering Education.

Section E, 14.

Section F, 42. American Microscopical Society.

Section G, 30.

Section H, 6. (No meeting of the section was held.)

Section I, 14.

Section K, 3. (No meeting of the section was held.)

Four persons registered indicated no preference as to section.

Section B and the American Physical Society had a joint program of 29 papers, in which no distinction was made between the papers furnished by the two organizations, the papers being arranged according to topics.

Section C held no formal meeting. Its secretary aided the representatives of the American Chemical Society in preparing the program of their

Ithaca meeting, and in making preparations for a joint meeting in New York. This society had a program of more than 80 papers, and its meetings were divided into sections.

The chemists constituted about one-third of the total attendance at Ithaca. The chemists and physicists together constituted about one-half of the total attendance.

It is interesting to note further that of the 231 members of the association registered, about one-half, or 121 to be exact, are members of the affiliated societies meeting at this time and place.

The geographical distribution of the members in attendance can be computed only for the 231 registered members of the association; of these, 94 come from New York State; 20 from Massachusetts; 17 from Pennsylvania; 16 from the District of Columbia; 12 from Ohio; 10 from Illinois; 7 from Michigan; 5 from Indiana; 5 from New Jersey; 4 from Canada, Kentucky and California; 3 from New Hampshire, Minnesota, Missouri, Connecticut and Virginia; 2 from Iowa, Nebraska and Maryland; and 1 each from Tennessee, North Carolina, Alabama, South Carolina, Mississippi, Vermont, Rhode Island, Wisconsin and Kansas.

The meetings of Section D were held on Friday and Saturday. They were followed by those of the Society for the Promotion of Engineering Education in the same room on Monday and Tuesday, with an attendance about 50 per cent. greater than that of Section D.

Section E held two sessions on one day for the reading of papers, and devoted the remaining three days to excursions to points of interest from a geological point of view, near the northern end of Cayuga Lake, near the southern end of Cayuga Lake, and at Enfield Glen.

Section F and the American Microscopical Society had a joint program.

Section G spent two and a half days in excursions to points of special interest from the botanical point of view, including a visit to Enfield Gorge. One day was spent in informal discussion of matters observed on the excursions. The Fern Chapter and the Society for Horticultural Science met at Ithaca just before the meeting of the association.

The attendance at the meetings of Section I was 25 to 40, considerably in excess of the registered number of members of that section (14). Nineteen papers were presented.

The relations between sections and affiliated societies were entirely harmonious in every case, the officers cooperating cordially in a common cause.

Cornell University placed its buildings at the disposal of the association, and each day furnished a mid-day lunch to the members. An appropriate resolution of thanks was adopted.

The following general events added greatly to the meeting:

1. The informal smoker at the Town and Gown Club on Thursday evening.

2. The formal opening and dedication of Rockefeller Hall, the magnificent new Physical Laboratory of Cornell University, on Friday afternoon,

with short addresses by President J. G. Schurman, Professor E. L. Nichols, Dr. Elihu Thomson, Dr. W. H. Welch (the president of the association) and a letter from Professor W. A. Anthony, read by Professor E. Merritt.

3. An address on Saturday evening by Professor Henry S. Carhart, of the University of Michigan, on "The South African Meeting of the British Association for the Advancement of Science," illustrated by a most excellent series of lantern slides.

4. A reception on Monday afternoon by Dr. and Mrs. Andrew D. White at their residence on East Avenue.

5. A public address on the recent California earthquake by Professor J. C. Branner, vice-president of Stanford University, given under the auspices of the local chapter of Sigma Xi in commemoration of the twentieth anniversary of the founding of the society. This was immediately followed by a Sigma Xi banquet, which was largely attended.

There were during the meeting, both within and outside of the council, various discussions of the relations of the association and of the affiliated societies. The only resolutions passed by the council bearing directly upon this matter follow:

*Resolved*, That the secretary of each section be required to prepare for the New York meeting a program of general interest for at least one session of his section.

*Resolved*, That the secretaries of the section be requested to confer with each other, and with the secretaries of affiliated societies, regarding the relation of programs for the New York meeting, and

Further, That the sectional committees be empowered to turn over technical papers to the technical societies, and

On motion, the permanent secretary was instructed to prepare a list of members of the association who belong to the affiliated societies accepted as possessing proper qualifications, and to submit these names to the council at the New York meeting, with the recommendation that they be elected as fellows.

The social features of the meeting were unusually pleasant; and, although there was no central rallying point for all the scientific people in attendance, except the luncheon place at 1 o'clock, the opportunities for social converse were many.

The Ithaca meeting will be remembered by those who attended it as one of moderate size, thoroughly successful as to number and quality of papers presented, characterized throughout by harmonious relations, especially notable for pleasant and profitable excursions, and given a tone of peculiar charm by scenic surroundings unrivaled by those of any other college campus in the United States.

The addresses made at the opening general session in Barnes Hall on Friday, June 28, are appended to this report.

JOHN F. HAYFORD,
*General Secretary.*

The first general session of the association was held in Barnes Hall, Cornell University, at 10 o'clock on Friday morning, June 29, 1906. The president of the association, Dr. William H. Welch, after calling the meeting to order, introduced Dr. J. G. Schurman, president of Cornell University, who delivered the following address of welcome:

LADIES AND GENTLEMEN: I have very much pleasure, on behalf of the university under whose auspices you meet, to extend a cordial welcome to the members of the American Association for the Advancement of Science, to the affiliated societies and to the friends who accompany them here. We feel it a great honor to have under our roof so large a gathering of distinguished scientists from all parts of the country.

I notice that you have timed your meeting so that you may be home by the Fourth of July to properly celebrate that day. I was thinking that if you practised on this occasion the scientific habit of analysis, and asked yourselves what was especially worthy of celebration in the day, you would perhaps sum it up under two or three heads. One of them undoubtedly would be the fact of a great nation of freemen governing themselves. The second, I think, would be the splendid mechanisms for the production and transportation of economic commodities which this republic has developed since the first Declaration of Independence. And I think the third would be the unusually high level of material comfort which the great majority of our population enjoy. You see I have made a close connection between the third of July and the fourth. If I am right in the analysis I have made, and have described correctly the three most important things that this republic has to celebrate as each fourth of July returns, we can recognize that two of them, at least, are the results of the labors of scientists. We cannot, perhaps, attribute to scientists a larger share than we attribute to other citizens in the bringing out and maintaining of a free government, but if we have our splendid system of economic production, and if the tide of material comfort runs higher here than anywhere else on the globe, it is due, first of all, to the abundant resources of our country, and secondly to the discoveries and investigations for which scientific men are responsible. And when I say that scientific men have in this way helped to produce two out of the three most important things which characterize our own republic, I do not feel that I have exhausted their highest work, for science has during the last hundred years revolutionized the civilization of the world. It has in other countries, as in our own, increased material comforts, multiplied inventions, and extended knowledge. It has introduced new modes of thought and new standards of evidence. The civilization of the earlier centuries was colored and molded by hearsay and tradition, whereas one of the most splendid achievements that has come to our age through the advance of science is the resting of knowledge on evidence, and on theory and hypothesis only as they are maintained by it. No one who has studied the thought and considered the progress of the world in its highest spiritual aspects can feel that I have stated the fact too strongly in saying

that science has revolutionized the civilization of the past—first of all, that of Europe and of America, and later that of Asia also.

So, ladies and gentlemen, we at Cornell University feel it a great honor to have in our midst for a number of days the representatives of those men and women who by the achievements of their labors and intellects are really shaping the advance of nations and molding the civilization of mankind. I am not certain that we can adequately show you the honor which we feel. We labor under a certain disadvantage, for it is now vacation and many members of our faculty have left their homes, but what it was in our power to do we have done. We have placed the facilities of the university here freely at your disposal. Ithaca is not as well provided with hotels as some of the larger cities, and so to supplement our local resources in that regard we have opened Sage College, and the graduates and undergraduates who control fraternity houses have also thrown them open. Our members will be ready, as the announcement explains, to take excursions to different parts of the surrounding country. We believe that we have here the most beautiful and most romantic college or university campus in the world. What lies in our power we are anxious to do. Our trustees have arranged for a luncheon to be served to you daily in the University Armory during your stay. I hope, Mr. President, you will not expect too much of us. We have done the most we could in the way of entertainment, and we hope you will accept the will for the larger deed which might have been possible in Washington, Baltimore or New York.

Ladies and gentlemen, once more I express the great pleasure we feel in having you with us, and in the name and on behalf of Cornell University I put what we have at your free disposal.

President Welch then introduced the Hon. Bradford Almy, mayor of Ithaca, who welcomed the association to the city in the following address:

MR. PRESIDENT, AND LADIES AND GENTLEMEN: The people of this city rightfully feel that this is an important event with them. They feel that Cornell University, the institution in which they take so much pride, is the cause of their having the pleasure of your visit to our city at this time. That an organization so eminently distinguished as the American Association for the Advancement of Science, composed of individual leaders in thought, labor and achievement along all the lines that lead to the progress, welfare and happiness of our people, should assemble in Ithaca for their deliberations is a compliment which we sincerely appreciate and for which we are very glad.

The profound sense of gratitude which we all feel for the heroes, self-sacrificing in their labors as pioneers of science, who caused a ray of light to shine here and there in the utter darkness, may perhaps be a measure of the feelings which we have for you men and you women who are laboring along lines of work so persistently followed and so diligently wrought out for the benefit of mankind and the civilization of the world. We can all remember, for it was not so very long ago, when science and religion were

believed to be at war with each other. That thought delayed its progress for a time, but science has made great advance during the years since that idea has left the minds of men. Happily, those times are past, and to-day science is regarded as more than the handmaid of religion. In bidding you the hearty welcome to our little city, which I have the honor and pleasure of extending to you on behalf of our people, I bid you Godspeed in the noblest work that can engage the thoughts and energies of mankind. At the same time, while we are conscious that the advancement in the last fifty years has been so great and so strengthens the courage and inspires the zeal for future work, we realize how diminutive are the regions of the known compared with the vast, untrodden wilderness on the border land of which you stand.

In closing, let me express the wish that you may have as prosperous a congress here as you have expected, that you may enjoy your visit as much as we hope you will and that you may go away with pleasant recollections of us and of Ithaca.

President Welch made response to the addresses of welcome, as follows:

LADIES AND GENTLEMEN: In behalf of the members of the association, of our guests and all here present, I wish to express to you, President Schurman and Mayor Almy, our very cordial appreciation of the words of welcome which you have given us. This is the first meeting of the association in Ithaca. It is also a renewal of an old custom of holding a midsummer meeting, and I do not know where that renewal, somewhat experimental, of the old custom could be inaugurated under more favorable conditions than in this place. Where could this association feel more at home than here at this home of learning and of science? It must, I think, be a satisfaction to the members at Cornell University to be enabled to show to their fellow members in this association the splendid opportunities which exist and the evidences of the great work done here, and it is equally a pleasure and source of profit to us to enjoy this privilege. We know that this is one of the great and leading universities of the country; that when it was founded Cornell University was enabled to do a work that was highly distinctive and significant and which marked a great advance in higher education in America, and that this position of leadership it has never lost. It is a great delight to come at this time of the year to this charming town and enjoy the wonderful beauties of nature in this region. They appeal not only to lovers of science, but to lovers of nature as well, and it would seem that the study of natural history must be stimulated by such surroundings as exist here. So, I say, we are particularly fortunate in coming to Ithaca and to Cornell University at this time.

The American Association for the Advancement of Science has had a very useful and honorable history. At the time it was founded, and for many years afterward, it was possible for a single association to represent in a very definite and concrete way all the existing natural and physical science in this country. During this period the scientific activities of the country were represented more adequately and comprehensively in this

association than in any other body. But at time went on, science in its various branches extended and grew, conditions changed, and it became evident that it was necessary for the association to adjust itself to those new conditions, the main one being the specialization of scientific work. That specialization has been a great instrumentality in the progress of science throughout the world, but nevertheless it has certain disadvantages and even dangers of its own. I believe that the highest function of this association is to try to minimize to the greatest possible extent the dangers that may arise from the minute subdivision of scientific research. As its name implies, this association represents a central body for the advancement, and, it may be added, the diffusion and the organization of science in America. It may be at times a little burdensome for active workers in one department of science to feel interested in the central organization, but I conceive it to be their highest duty to do so. They should consider the interests of science as a whole in this country, as well as those of their particular branch of science, for unless the whole tree of science flourishes the branches will suffer.

This association represents, as it were, an association of various special scientific societies, perhaps more than an association of various scientific workers. It is necessary to have this coordination of societies in order to bring together the great body of scientific workers throughout the country, but in the plan of our organization the affiliated societies in no sense lose their autonomy and it is essential that they should not. The centers of scientific activity in this country are not concentrated in a few points, as in most European countries, and it is believed that this plan of organization best meets the special conditions of science in America.

It is very important, under our form of government, that there should be a central authoritative voice which speaks for science. How many questions there are, as has been suggested by President Schurman, relating to the highest welfare of society which can be solved only by science, and how important it is that workers in kindred subjects should be brought into contact with each other! There are matters of education, matters of public policy, and matters of research in all departments of the government and of national life that sustain very close relations to the opinions of scientific men, and it is, therefore, of first importance that there should be a body which can express in an authoritative and representative way the scientific opinon of the country.

This experiment of renewing the midsummer meeting indicates in a measure the great growth in membership and in influence of this association. In so doing, of course there is no intention of abandoning the meetings in the winter. It was necessary, in bringing about a proper adjustment of the work and aims of the association to the specialization of science as represented in the various affiliated societies, to adopt the plan of a winter meeting, but the association, while gaining much, undoubtedly lost something by it. Certain members, desirable to have with us, were unable to attend, and the more popular side of the work may have suffered

somewhat because of the more special and technical character of the papers presented at the meetings in the winter. There are many, such as school teachers, amateurs and others intelligently interested in natural and physical science, but not actively engaged in research, whose support and interest it is desirable that the association should secure and who formerly attended the summer meetings. It is to be hoped that this effort to renew that kind of work and influence of the association which was expressed in the old days by the midsummer meeting will be successful and this extension of influence can be secured without any impairment of strictly scientific aims. As I have said, we certainly could not inaugurate the movement under better conditions than at this time and in this place.

This is the first opportunity that I have had to appear in my official capacity before the association, and I wish to express my appreciation of the distinguished honor which was conferred on me at the meeting in New Orleans. The honor is not merely a personal one, but I interpret it as a recognition of medical science as an integral, coordinate part of the natural science of this country; and medical science, in my judgment, fully merits this recognition on account of the paths which it has opened up and followed and the great advance which it has made in recent years.

President Schurman has indicated to us the intimate relations which science sustains to the highest interests of society throughout the world, and this condition has been brought about largely through scientific discoveries and their application to useful purposes. It is the glory of medicine that in these later days it has been able to contribute its share, a share not unworthy of its rank among the sciences of man and of nature, toward the advancement of useful knowledge. It has done so partly by recognizing the fact that a large part of medical science is essentially biological science, and that this is not only true of normal anatomy and physiology, but that pathology, the science of disordered structure and function, may be considered and cultivated to a large extent as biological science. This has been one of the reasons for the great advance in medicine. The scientific method, the method of observation, experiment and reasoning, in contrast with the dogmatism, speculation and reliance on authority which for centuries dominated the history of medicine, is recognized to-day by medicine as fully as by any science as the only source of fruitful progress.

But above all, it has been discoveries resulting from the opening up of new paths of investigation which have impressed both the scientific and the popular mind with the importance of medical science. In the last three decades medicine has advanced to a postion where it stands as never before in the very closest relations to the highest interests of human society. When you consider the vast accumulations of population in cities, the great industrial activities of modern times, the efforts to colonize and to reclaim for civilization tropical countries and waste lands, such a stupendous undertaking as the digging of the Panama Canal, all dependent in a very direct manner upon our power to control the spread of epidemic

and endemic diseases, and that this power has come from the discovery of parasitic micro-organisms and the study of their properties and of the manner of propagation of agents of infection, it must be clear to you that medicine, especially preventive medicine, is most intimately related to the progress of civilization and the advancement of human society. So the time has fully come for medical science to stand side by side with other sciences and to be represented with them in this association.

I was expected on this occasion not to make a formal address but simply to reply to the cordial words of welcome which have been extended to us on behalf of the university and of the city. The evil day, fortunately for you and for me, seems by the plan of organization to be put far off, when the incoming president is expected to make his formal address to the association.

I now have pleasure in declaring this fifty-sixth session of the American Association for the Advancement of Science open, and I trust that the sessions of the association and the meetings of the several sections and affiliated societies will be full of interest and profit to all in attendance.

After announcements by the general, permanent, and local secretaries, the general session of the association was adjourned.

CLOSING SESSION, TUESDAY AFTERNOON, JULY 3, 1906.

The closing session of the association was held in Barnes Hall, pursuant to adjournment. At 2 o'clock the President, Dr. W. H. Welch, called the meeting to order and said:

LADIES AND GENTLEMEN: We were all disappointed that one of the speakers who was announced on the program of our opening session was unable, in consequence of other important engagements, to be with us at that time. There is no one we would have been more glad to hear; there is no one who is more welcome in an assemblage of scientific workers, no one who has told the story of the Warfare of Science so graphically as he has done, and no one who has fought more vigorously the battle for natural and physical science. We are very fortunate this afternoon in having the privilege of listening to an address by that great educator, statesman and man of letters, called here in Ithaca most appropriately, I think, President White.

Dr. WHITE: Mr. President, and ladies and gentlemen: As I look into your faces, there comes back to me very vividly my first experience in the American Association for the Advancement of Science. It was in the city of Albany, just exactly fifty years ago, in the summer of 1856. It was a great event. Nothing could have been finer than those parts of it which the great crowd there assembled came to see. Although the occasion of that meeting was the opening of the Dudley Observatory, the object of the gathering was not so much the doing of work by scientific men, as it was a general glorification of science, and certainly no one feature of the program so magnificently wrought out as was the address by Edward

Everett. The meeting was in the open air, in Capitol Park, and was more like a political meeting than a scientific one. The occasion was honored by the presence of Mr. Bancroft, than whom no one was more respected in the United States, and there were also present Professors Henry, Beard, and Agassiz. We all loved and honored Agassiz; we admired him and almost adored him, but we loved and honored him more when he assured us that there was absolutely nothing in the Darwinian theory!

In looking back, one can see that those were the days of small things in science. I remember that while a student at Yale, where we boasted of great opportunities for the study of science, there was no one in my class of 109 members who had the slightest aspirations in a scientific direction. I doubt whether one per cent. of the students at Yale dreamed of approaching anything like science in the remotest way. I recall here, as I have many times before, when the old wooden house on the campus, which had been occupied by the presidents of Yale, was taken for the purposes of a students' laboratory, the beginning of the Sheffield School; and I remember how one morning, [illegible] out of my room in North College—the room which your honored [illegible]nt afterwards occupied—and seeing a large, fine-looking fellow [illegible] seemingly intelligent, holding something up in a test tube and looking at it, the thought came to me, "What a futile occupation for a man with an alleged immortal soul!" Yale in those days, with such men as Silliman and Olmstead, was considered a great center of science; the function of science, it was believed, being to enable a young man, when the word was mentioned in polite circles, to appear to know something about it, but any investigation of scientific subjects was not thought of. I am sure that the whole mass of physical and chemical apparatus, of which Yale at that time was specially proud, could have been put in the smallest recitation room in this university. Going afterwards as a professor to the University of Michigan, I found that there was no instruction in physics then being given, and all of the physical apparatus could be put in a wardrobe of moderate size. It was a great pleasure to me yesterday to meet here the one who came there, as a young man, from the Rensselaer Polytechnic Institute and began the work which has since reached such large proportions in that place.

We have seen immense progress since those days. We have seen the earlier ideals of students thoroughly changed, and changed for the better. In our institutions of learning we now find greater provisions for scientific studies in every direction. We may congratulate ourselves and our country upon these facts. I certainly congratulate you, in taking leave of you, as you go back to your accustomed fields of labor, that there has never been a time when science was held in such high honor and so nobly cultivated as at present. It makes me hopeful that some things in this country which we now greatly deplore are going to be remedied, and one of them is what I call the present wretched administration of justice, especially as regards high crime. It makes an optimist of me, to know

the increased place which science has taken in every field, and which it must in the future exercise in those fields which have to do with government. I believe that there is a great future for those sciences that apply to problems that shall arise in our national life. I believe that more and more the necessity of knowledge and experience in the sciences that apply to important political questions will come to be known. I believe that more and more the scientific spirit and scientific methods as cultivated in every field are to be of use in uplifting this nation out of many things which we now condemn. I am not in the slightest degree a pessimist; I am far more an optimist, and I cannot but compare the condition of things here with those in that other great country which is beginning to grapple with evils which have long been suppressed in our own.

It has been a great pleasure and a great honor to Cornell University—I have felt it so and I am sure my colleagues have—that you selected this city as your place of meeting. It was my fortune to do some work on this hill before the rail fences had disappeared from the campus, and before even a stone in these buildings had been laid. I indulged in some rather lofty dreams. I built many castles, but never, in my wildest dreams nor in my most hopeful hours, did I imagine that I should see the time when the American Association for the Advancement of Science would feel that this was a place which was sufficiently attractive to make it their home during one of their meetings. I feel that it is a recognition of which we have a right to be proud and I thank you for it; and in the name of the trustees, the faculty, and all connected with the University, I invite you to come again. Come at the earliest day that is possible for you, and my hope is that you will find still further progress here, and that we shall have the pleasure of a renewed acquaintance with you. I thank you most cordially for this visit. I bid you a most hearty farewell, and I renew my congratulations that you are going forth into a country prepared for you such as no country has ever been prepared for a body of scientific workers.

THE PRESIDENT: For myself, and in the name of the association and of all here present, I thank you, Dr. White, for coming here and speaking these very inspiring words.

There has been a number of interesting features connected with this meeting, and it is customary at our final session to have some statement made in regard to those things. Dr. Howard, the permanent Secretary, has consented to present that statement in the form of a report.

## GENERAL REPORT ON SOME FEATURES OF THE MEETING.

The meeting just concluded has been the fifty-sixth meeting of the American Association for the Advancement of Science.

It has been the first summer meeting held since that at Pittsburg, in June, 1902. In the meantime, in convocation week, four mid-winter meetings have been held, namely, at Washington, at St. Louis, at Philadelphia and at New Orleans.

The return to the summer meeting plan has been experimental, and while, as prophesied by certain members, the meeting has not been largely attended, it has been an enjoyable one from every point of view, and a successful one from several points of view.

In estimating the attendance of the scientific men and women present, it is found that 231 have registered for the American Association for the Advancement of Science; and that 94 of those registered for the American Chemical Society are not members of the Association. This makes 325, and the additional registration as yet not computed in the same way, from the American Physical Society, the Society for the Promotion of Engineering Education, the American Microscopical Society, and the Society for the Promotion of Horticultural Science, will swell the list to a number surely reaching 400.

It is interesting to note further that of the 231 members of the Association registered, about one-half, or 121, to be exact, are members of the Affiliated Societies meeting at this time and place.

The geographical distribution of the members in attendance can be computed only for the 231 registered members of the Association; of these 94 come from New York State; 20 from Massachusetts; 17 from Pennsylvania; 16 from the District of Columbia; 12 from Ohio; 10 from Illinois; 7 from Michigan; 5 from Indiana; 5 from New Jersey; 4 from Canada, from Kentucky and from California; 3 from New Hampshire, from Minnesota, from Missouri, from Connecticut and Virginia; 2 from Iowa, from Nebraska and from Maryland; and 1 each, from Tennessee, North Carolina, Alabama, South Carolina, Mississippi, Vermont, Rhode Island, Wisconsin and Kansas.

Of the ten sections of the Association, eight have held important meetings at this time and place. Section B has met in affiliation with the American Physical Society, and has had a strong joint program.

Section C has met in affiliation with the American Chemical Society and the New York Chapter of the Society for Chemical Industry; the program was long and important, and was completed in the sessions of three days, Thursday, Friday and Saturday.

Section D has met in affiliation with the Society for the Promotion of Engineering Education, and has had a joint program.

Section E has had an independent meeting devoted largely to field excursions, but has listened to six papers.

Section F has had an independent program, consisting of sixteen papers read in three sessions, on Friday night, Saturday morning and afternoon, and has also met in affiliation with the American Microscopical Society, which has presented an independent program of papers.

Section G has held an independent meeting devoted entirely to field excursions.

Section I has had an independent meeting of importance comprising four sessions, at which twenty-three papers have been read.

The social features of the meetings have been unusually pleasant; and,

although there was no central rallying point for all the scientific people in attendance, except the luncheon place at 1 o'clock, the opportunities for social converse have been many, and the interest attaching to the great and well endowed University, and the great scenic beauty of the Campus and the city of Ithaca and of the surrounding country, together with the most cordial hospitality of the faculty of the University and the residents of the city, have combined to make the meeting one to be remembered.

THE PRESIDENT: Dr. Howard, in closing his report, speaks of the extraordinary hospitality which we have received here. A special committee was appointed by the council to draft and present proper resolutions on that subject. Dr. Woodward, as chairman of that committee, will present those resolutions.

Dr. WOODWARD: We feel very keenly how inadequate are any words to express our thanks and gratitude for all that we have received and enjoyed here. My associates on this committee were Dr. Howard and Mr. Benjamin. My own part of the work was to eliminate any crudities that there might be in the resolutions and then read them to you. So, if any remain, you may accuse me of oversight.

Mr. President, I move the adoption of the following resolutions by the association:

### REPORT OF THE COMMITTEE ON RESOLUTIONS.

The American Association for the Advancement of Science and the Societies that have met in Ithaca at this time with the association, have very much to be thankful for, and your committee has endeavored, in an all too feeble way, to express these thanks for the association and the other scientific bodies, in order that they may be made a matter of record.

We wish to thank, in the first place, this great institution of learning, Cornell University. We thank the University for the invitation to visit Ithaca, originally sent to us some years ago, and repeated from time to time, personally and by letter, in the most cordial way.

We thank President Schurman for sending these invitations, and for his courtesy in returning at great personal inconvenience from his summer home, in order to deliver an address of welcome, at the opening session Thursday afternoon last.

We thank the Trustees of the University for placing the buildings and laboratories at the disposal of the association; for opening the Sage College dormitories to our occupation, and for the all-sufficient and delightful luncheon that has been given to us daily.

We thank the faculty of the University, in all of the scientific departments, and many other departments, for very many different things. We thank, especially, those who arranged and conducted the numerous delightful excursions which have been made from Ithaca as a center, during the past few days; the arrangements have been perfect, including an occasional shower—not under the control of the faculty—and the conductors

for so conducting them as to convey the necessary useful information without appearing to resemble in any way the useful, but maligned tours of the Messrs. Cook.

We thank the town of Ithaca, and especially his honor, the mayor, Mr. Almy, for his cordial address of welcome; its citizens who have served upon the local committee; its Business Men's Association for their hospitable endeavors; and all Ithacans who have contributed in many ways to our comfort.

We thank the board of directors of the Town and Gown Club for throwing open the charming club house on Cascadilla at all times during the meeting to the visiting scientific men. We thank the club and its members for the enjoyable "Smoker" of last Friday night; and we thank the men who sang the Cornell songs for the enjoyment and enlightenment of the visitors. We thank, as well, Mr. L. A. Fuertes for the extraordinary stories he told that evening.

We thank the different fraternities, so abundantly represented at Cornell, for opening their beautiful houses for the resident accommodation of members, enabling us not only to enjoy most beautiful quarters, but to gain an insight, in a measure, into the development of fraternity life for which Cornell is almost unique.

We thank Dr. and Mrs. Andrew D. White for the Reception of Monday afternoon and evening, which was so greatly enjoyed by the members still remaining in the city; and we thank the other members of the colony on the hill, for the many dinners, luncheons and receptions given to groups of members of the association.

We thank Professor Carhart and Dr. Branner for the admirable complimentary lectures given on Saturday and Monday evenings.

Especially we wish to thank the chairman of the local committee, Professor E. L. Nichols, and the local secretary, Professor W. W. Rowlee, for their untiring and most successful efforts to make the meeting as great a success as the association, and the Cornell and the Ithaca people could wish.

Finally, we thank the Lehigh Valley Railroad Company for the courtesy shown in the excursion to the George Junior Republic, at Freeville, and we thank the Ithaca newspapers for the space they have given to the deliberations of the meeting.

All of these numerous thanks your committee offer as a single resolution for the adoption of the association.

C. M. WOODWARD,
L. O. HOWARD,
MARCUS BENJAMIN.

ITHACA, *July* 3, 1906.

The motion to adopt the resolution was seconded, and carried by a rising vote.

Prof. Edward L. Nichols, chairman of the local committee, announced

that immediately after the adjournment of the meeting, Rockefeller Hall, the new home of the Department of Physics, would be open to the association for inspection.

THE PRESIDENT: Nothing, practically, remains for me to say in bringing this meeting to a close. Everything that occurs to me has already been said, and expressed better than I could do it. I think we shall leave here with enduring impressions, not only of the hospitality we have received, but of the almost unrivalled opportunities which exist here for the cultivation of science and learning. I had never had an opportunity of visiting Ithaca before, and I know there are many others here who had not enjoyed that privilege. I think it must be gratifying to the members of the University that they have been enabled to give us the impressions which we shall bear away.

This meeting has been a delightful one, and I think we may say that the claims of those who advocated a return to the midsummer meeting as a part of our work have been justified by the success achieved here. The special purposes, of bringing together into intimate, close relations the members of the association, and adding certain distinctive features which pertain so such a meeting—notably, the excursions—have been successfully carried out. I think it will be an impossibility to attempt elsewhere to duplicate what we have had here. Where else can we find such combination of natural beauty of region with the attraction of a great University? This meeting, in the renewing of the old custom, will be memorable, and also because of the particularly distinctive successes which attach to it. I wish, in my personal capacity, to express my gratitude for all that has been done here.

I now declare this fifty-sixth session of the American Association for the Advancement of Science closed.

# THE FIFTY-SEVENTH MEETING

## NEW YORK, N. Y.

DECEMBER 27, 1906, to JANUARY 2, 1907.

## WINTER MEETING

# ADDRESS

BY

## THE RETIRING PRESIDENT OF THE ASSOCIATION.

ADDRESS

BY

CALVIN M. WOODWARD,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

## *THE SCIENCE OF EDUCATION.*

The record of the year 1906 exhibits so many kinds and degrees of progress; such evidence of improvement in national and international well-being; such a development of the arts of peace in all lands; such exhibitions of zeal, individual and social, in behalf of corporate and governmental integrity; such abundant industrial and commercial prosperity; and finally such a universal tendency to promote education, to advance science and to foster higher standards of civilization—in short, the year just past is so full of noble endeavor, and endeavor crowned with success, that I stand almost mute in the presence of what ought to be said of the advancement of science, as science grows from more to more, and more and more is applied to the myriad arts of life.

I agree heartily with Huxley and others that there is no valid distinction between pure science and applied science. The final test of the value of what is called science is its applicability, and it is one of the signal triumphs of the last few years that much of what was rated as "pure science," and "pure" because useless, has proved to be invaluable either in widening the boundaries of scientific attainment, or in the development of the useful arts.

All genuine science should be both pure and applied. In a word, let the purity and the application be taken for granted;

and let every man who finds in the formula of the mathematician, or in the formula of the chemist, or in the formula of the biologist, the key which unlocks the storehouse of nature's secrets; solves a hitherto unsolved problem of matter; or throws light upon one of the hard questions of vegetable or animal life, still claim that his science is pure, when science enables us to invent a new prime mover, to produce a new material of construction, or create a new article of food, let us give credit where credit is due—to science, and to associations which aim to advance all true science and which foster every effort to make that science useful to mankind.

The false, though inherited, notion that polite learning and true culture admit no contact with utility, is, thank Heaven, fast dying out. Occasionally a voice from the "inner circle" shouts gleefully: "Here's to mathematics! May she never be prostituted to any human use!" But we can afford to smile at the conceit of such a Levite of culture, and pity him for his narrowness and lack of human sympathy. However, those "pure" scientists often build better than they know. Even the professor who boasted that he had never wittingly either learned or taught anything useful has become the servant of real learning by extending the limits of scientific knowledge, which refuses to be hindered or circumscribed by its mistaken votaries.

There is, as every careful observer can testify, an abundance of useful fruit in every department of scientific research. Note the uses of electricity, chemistry and thermodynamics; of botany in fruit culture; of bacteriology in the warfare for human and animal health; and how the discoveries of science in a hundred fields are made useful in inventions for the transformation, transmission and utilization of energy.

It is not my purpose to point out the progress made during the past year in the discovery of scientific truths, and in their utilization in the various directions indicated by the different sections of this association. The task would be too great for me or for any one man. The printed reports and proceedings of the sections themselves will furnish the best permanent record. It is, however, my purpose to call the attention of the asso-

ciation to the importance of the science and art of education, and to suggest the propriety of creating a new section devoted to the advancement of the science of education.

## THE SCIENCE OF GOOD GOVERNMENT.

Before taking up the subject which, for fifty years, has been more or less directly my life and my delight, I desire to express my estimate of the unparalleled achievement of our national government in the interests of peace and international brotherhood. I refer, of course, to our intervention, in accordance with our contract with Cuba, to restore and maintain peace, order and good government in that long-suffering and badly-educated island. Never before, in the history of the world, did a strong nation go with an army and navy to the aid of a weak and inexperienced nationality when it was torn into factions by jealousies and distrust so deep and bitter as to overcome their desire for good order and self-government; and then, without firing a shot or taking a prisoner, establish order, disarm hostile bands, promote mutual confidence and restore the occupations of peace; and finally, having accomplished this remarkable feat, never did such an army and navy come home again, with no booty, with no trophies, with no captives, with no triumphal procession—with nothing but the consciousness of having done an act of international good-will. The spectacle is one for the world to look upon and admire. There is most surely a science of good government, and that science we, as a people, are rapidly advancing in this western world.

Let no one try to take away from the essential nobility of this act by pointing to the interest of a few American planters in Cuba. We are glad to have their interests protected, but those interests were relatively unimportant, and I firmly believe that had there not been an American planter or merchant in Cuba, our government's course of action would have been just the same, with the same splendid result. So let not the glory of this transaction be dimmed by unworthy detractions or by neglect. It was a great and noble work two years ago to prevail upon Russia and Japan—when those two nations stood face

to face, each with an army of half a million men, ready to crush and slay till the blood of a hundred thousand young men should again stain the soil of Manchuria—to stop fighting, to withdraw their forces, and to submit the issues of their quarrel to a council of peace. That was a great work, and we glory in its accomplishment—but the work done in Cuba is not less fine, though less spectacular. Its modesty, its example of purity and restraint, of justice and respect for law, its vindication of the principles and duties of a republic—all combine to make this year of our Lord 1906 an epoch in international courtesy if not in international law.

## EDUCATION IN THE ARTS OF PEACE VS. EDUCATION IN THE ARTS OF WAR.

One word more of immediate interest. The great exposition at St. Louis, in 1904, gave an epitome of the civilizations of all the nations and tribes of the earth. Their representatives dwelt or camped side by side and exhibited with marvelous fidelity and fullness their industries, their commerce, their science, their art, their systems of education and their modes of life. It was, indeed, a great educational institute carried on for seven months in the presence of millions of visitors from every nation under the sun. Probably no human instrumentality was ever more potent in promoting the advancement of science than that exposition. The great congress brought together the best of living men, and they offered their best tributes for the service of science and human progress, and we had the supreme spectacle of the triumphs of the arts of peace.

The exhibit of instruments designed to kill human beings, and of appliances for the destruction of ships and forts, was minimized, and the pageantry of war offered few attractions and claimed small attention. The glory of the exposition was its devotion to education, and the application of science to the useful arts.

I have thus characterized the exposition of 1904, in order to show more clearly what I consider an unfortunate tendency on the part of the management of the proposed Jamestown

Exposition at Norfolk, Va., in 1907. I refer to the prominence which military and naval exhibits and evolutions occupy in the prospectus of attractions. The emphasis would seem to be on the science and the art of war, as though the glory of our American manhood lay in our ability to overawe, crush and destroy the very peoples who, two and a half years ago, joined hands with us and with each other in fostering the growth of an international brotherhood which should relegate the waste and horror of war to the pages of history.

Are we not in danger of cultivating overmuch a warlike attitude and of encouraging the growth of a taste for warfare? The maxim, "In time of peace, prepare for war," has done infinite mischief. It has misled statesmen, and sent millions upon millions of young men to untimely graves. It means arsenals and forts, great standing armies and vast fleets of battleships; and yet those are the very things we wish to reduce to the lowest possible terms. I approve of a single military academy and a single naval academy, since both are needed by a modest army and navy; but I do not wish to see military academies multiply, nor would I have the mimicry of war become a pastime in our schools. I doubt if a correct science of education will include the science of shooting our fellow-men. The episode of the early Jamestown was not a military campaign nor a naval victory; it was rather a step in the conquest of nature, and a chapter in human progress. I trust it is not too late to give to the Jamestown Exposition a tone less warlike, and to put the emphasis where it must in future belong, upon education, science, industry, commerce, and social progress.

## EDUCATIONAL THEORIES, ANCIENT AND MODERN.

Coming now to the special message of this address, I propose for your serious consideration the organization of an additional section devoted to the "science of education."

As one looks over the history of education he is struck by its chaotic condition. From Aristotle to the men now living, we find the problem of education discussed from many points

of view, with many different objects in mind, and under widely different social conditions.

The Greek idea of education and culture was based upon the existence of a privileged class, fed, clothed and sheltered by the labor of slaves—a real aristocracy devoted to war, art, literature and luxurious living. The sway of the so-called classic idea of education has been and still is one of the marvels of history. The splendor of Greek art, the brilliancy of Greek literature, and the keenness of Greek logic have held the world as in a trance, unable to break away from its charms—though it has been unsuited to other peoples and other social conditions.

I need not turn the pages of history to name the writers and teachers who have risen in protest or set forth new doctrines. In many cases the new prophet or teacher has had in mind a privileged individual, or a privileged class, the education of a prince, of a nobleman, of a statesman, a monk, a scholar, a gentleman—always an exceptional person or class. The common people, the toilers in the fields and mines, the rank and file of soldiers and sailors, the builders of houses and ships, the craftsmen at looms and benches—for all such there were no educational theories. Such people had no education and they were supposed to need none beyond that gained in following the occupations or crafts themselves. The assumption was not only that there was no education suited to the common people, but that an interest and participation in the practical arts was degrading to the taste and deadening to the mind. To be sure, a Rabelais or a Rousseau saw abundant reason for rebelling against the scholasticism of the grammarians, and advocated a return to a study of the external world and the methods of controlling and utilizing the forces of nature, but even they had no science of education, and they had small following.

## THE RECOGNITION OF UTILITY AND SCIENCE.

Francis Bacon, more than any other man, showed the inadequacy of the classic method, fine as it was along certain lines, and the comparative worthlessness of scholasticism, and he opened the eyes of the educated people of his time to the wealth

of opportunity for interesting and profitable study in the great laboratory of nature; and better than all else, he set forth the dignity and intellectual value of science study—and he vigorously scouted the idea that the usefulness of scientific truth to any degree detracted from its educational value.

But none of the writers touching on education, with the possible exception of Froebel and Pestalozzi, not even Locke, Milton or Dr. Samuel Johnson, looked at the matter from the scientific standpoint which takes into account: first, the physiological laws which govern the growth and development of the brain; second, the exterior stimuli for promoting that growth most successfully; and thirdly, the kind and quantity of knowledge and skill one must have in order to meet most completely the demands of a carefully-selected occupation.

The history of education is full of the records of whims and fancies, of experiments real and imaginary, conducted in order to prove the worthlessness of some theories and the worthiness of others. Every parent has a dimly-defined theory of how his boy ought to be educated, and every teacher looking back over his own experience as a pupil formulates more or less clearly a "system" for the proper education of his pupils. It goes without saying that such theories and so-called systems are generally shallow and inadequate, and I say this with no disrespect to either parent or teacher. I am both a parent and a teacher, and I know only too well how inevitably we theorize and plan, and how inevitably we go astray through lack of scientific guidance.

I do not claim to have formulated the science of education, and I know of no one living who has ventured to make such a claim; and yet I believe that a science of education is possible—and it is high time that we set about a systematic study of its essential features with a view to a formal statement of its main principles. Where can that important work be begun and carried on more appropriately and successfully than in the American Association for the Advancement of Science? Here we can bring the results of long experiences under a great variety of conditions, with unequaled opportunities for comparison and elimination.

In his "Tractate on Education" Milton defined a complete and liberal education to be that "which fits a man to perform justly, skilfully, and magnanimously all the offices, private and public, of both peace and war." That is comprehensive enough, yet Milton had in mind only the offices which pertain to the five professions which were then open to liberally educated men, viz., those of the lawyer, the physician, the clergyman, the soldier and the gentleman. A "gentleman" as defined by Milton was one "who retires himself to the enjoyments of ease and luxury." He had no thought then, as had not the educational writers of ancient or medieval days any thought, of the sixth estate, the great mass of the people who are coming to be the characteristic force in the civilization of to-day, viz., those actively doing the world's work, the constructive and distributive, and providing agencies of modern life. We are offering education to-day to every child, a comfortable home to every family, citizenship and self-respect to every graduate of our schoosl. The education we must study is the universal education of the American people. We have put science, and ever more science, into the world's work; we must now give science and culture and skill to the world's workers.

When a privileged class lived in luxury, relying upon the labor of slaves who were purposely and sometimes legally kept uneducated, and when education for culture and the accomplishments of polite society were natural and logical, it was not surprising that philosophers should hold that practical affairs were degrading. Seneca, who lived in the first century, was indignant because Posidonius had so far forgotten himself as to credit philosophy with the invention of the arch and the introduction of the uses of metals.

Philosophy, according to Seneca,* "had nothing to do with teaching men how to rear arched roofs over their heads; and they were not concerned with the various uses of metals. She teaches us to be independent of all material substances, of all mechanical contrivances." The wise man, said the Roman philosopher, lives according to nature. Instead of attempting to add to the physical comfort of his species, he regretted that

*Episto, 90.

his lot was not cast in that golden age when the human race had no protection against the cold but the skins of wild beasts, no screen from the sun but a cave in the earth. To impute to a philosopher any share in the invention or improvement of a plow, a ship or a mill, was an insult. The invention of such things, wrote Seneca, is drudgery for the lowest slaves. Philosophy lies deeper. It is not her office to teach men how to use their hands. The object of her lessons is to form and nourish the soul.

The above wish of Seneca can be fairly paralleled by an utterance of Matthew Arnold in his famous essay on "Sweetness and Light" (a phrase he borrowed from Swift). Arnold asks, with no evidence of doubt as to the superiority of the "brave days of old:"

"If England were swallowed up by the sea to-morrow, which of the two, a hundred years hence, would most excite the love, interest, and admiration of mankind—the England of the last twenty years, or the England of Elizabeth, a time of splendid spiritual effort, but when coal and our industrial operations depending on coal were very little developed?"

That is, he would prefer an age when they had no mills, no canals, no steam-engines, no railroads, no steamboats, no manhood suffrage, no common schools, few books, few newspapers and few magazines, because a great majority of the people of England could neither read nor write. *De gustibus non*—as I always say of Ruskin.

I have quoted Seneca at some length because he is a type of a class of people ancient, medieval and modern, who, living like Seneca in great luxury upon their income, look with disfavor, if not contempt, upon all studies which have, or may have, a positive value in multiplying human comforts and in ameliorating human sufferings.

It is not many years since a president of Princeton University expressed his regret that the higher mathematics had been found useful in the study of electrical appliances, for, said he, "as the utility of a subject increases its educational value decreases." Such was the view of the fathers and the disciples of Greek philosophy from Socrates to Patton, but such was not

the view of Lord Bacon, and Lord Macaulay, and Professor Huxley, nor is it your view, I trow; certainly it is not mine. I would as soon adopt the educational scheme of Machiavelli as that of Seneca. The former in all frankness and candor pictured the intellectual and moral dishonesty and hypocrisy of his time; but his life was relatively clean. As for Seneca, he sang the praises of virtue and literary culture, and then closed his career by an exhibition of meanness, ingratitude and corruption which threw a blanket of infamy over his fine advocacy of a philosophy which was to form and nourish the soul.

Is it not evident from the standpoint of the subjects to be studied that we need a science of modern education? Educational values are to be determined, taking into consideration age, sex, environment, taste, brain development and probable sphere of usefulness.

### THE DOCTRINE OF INTEREST.

Here two important subjects crowd upon me for consideration, and they are just the subjects which I wish to lay before a section devoted to the science of education. They are closely related, and I suspect they are strictly modern. I refer to the doctrine of interest, as a valuable or as a harmful characteristic of study; and to the wisdom or the folly of a free election of studies in our secondary schools and colleges. Consider for a moment how much we are at sea and how far we have drifted apart on these two matters—and then you will agree with me as to the need of systematic study and observation that we may find our bearings and lay our courses correctly.

The question of taste and interest is a very perplexing one. Antecedent interest is, we all know, quite accidental and a very unsafe guide. The whims of boys and girls are generally due to the suggestions of companions and of external opportunity. It has been my fortune, as well as my duty, to warn hundreds of parents of boys from fourteen to eighteen years of age not to take seriously their early interest in particular studies or their haphazard plans for future occupation.

Some choice is inevitable, and plans for the distant future

are as plenty as castles in Spain, but nothing can be more evident than the unfitness of a boy in his teens to select definitely the course of study best suited to his inherited and acquired capacity; and nothing can be more certain than his practical ignorance of the conditions of a successful career. Hence his declared preferences and elections are to be treated with a loving sympathy, as are a hundred other youthful fancies, but the wise parent and the wise teacher decide to leave open all the avenues of culture and skill, and to hold off the great final choice till the boy has had time and opportunity to make two important discoveries, viz., the intellectual world within him, and the material and spiritual world without. Here we need the pronunciamento of science, telling us how much weight we shall attach to the preferences of a boy of twelve, of fifteen, of eighteen, in regard to the scheme of education and training which shall enable him to make the most of himself and be of the most use to his time and generation.

Every good teacher aims to make his subject as interesting as possible to his pupils. If they fail to take a lively interest in it, something is wrong; either it is not properly presented or it is over their heads; or it is clearly of no earthly use. Natural lack of capacity on the part of the child is rarely a valid reason for failure, if the child be healthy and normal. I have learned to discredit the truth of the oft-told tale that "John has no capacity for" such a subject—mathematics, for example. "He never could learn mathematics—he takes no interest in algebra and he hates geometry," etc. Our higher schools and colleges are full of young people who protest vigorously that they never could and never can understand, or take any pleasure in, or gain any profit from, certain studies. On the other hand, I firmly believe that every normal person, at least nine out of ten of the children and youth at school and college, can fairly master and actually enjoy and profit by not only mathematics, but by every subject in the curriculum, if it be properly taught, and under proper conditions as to age and preparation.

I know a man who when a boy was put too early and too rapidly to arithmetic, algebra, geometry, trigonometry and

analytics. He must have had the worst possible teachers, for he comprehended nothing of what he glibly recited from memory. So they called him a dunce, reported him home as a dunce, and the boy accepted the oft-repeated verdict and believed himself a dunce in mathematics. He would have gone through life with that conviction stamped into his brain had not chance thrown a West Point appointment in his way. Spurred by pride and ambition, he resolved to review arithmetic by himself and at least pass the entrance examination to the military academy. To his great surprise he found arithmetic easy to his maturer powers and very interesting, and he entered the military academy with flying colors. Then he took all of the mathematics which he had hated over again. They were a delightful revelation to him. He graduated among the engineers, a fine mathematician, and he is to-day at the head of an engineering school of high grade. I have the story from his lips.

I have had unusual opportunity to observe similar cases, and in a measure to help students who have been the victims of bad judgment on the part of teachers or parents, and so have been led or allowed to dislike subjects which they should have enjoyed, and to underrate their mental faculties because they had attempted to exercise brain cells which were not yet properly developed.

The importance of this subject cannot be overestimated. How many lives have been shortened; how many intellects have been dwarfed and stunted; how many careers have been partial failures—all due to early and inconsiderate teaching? Opportunities to redeem and save those of great possibilities, like the one I have mentioned, are rare, and the vast majority of victims never fully recover. In our zeal we have often overshot the mark. The proverbial intellectual strength and vigor of country boys coming up to the university is due not wholly to outdoor life, physical exercise and plain food. I am inclined to believe it is due in part, and perhaps a great part, to their escape from too much schooling and too much crowding. What the country boy needs (and what he often lacks) is not

so much longer sessions and rapid promotions as more accomplished teachers.

A word more about the importance of interest as a condition of healthy mental growth. I maintain that attention is as necessary to the growth and development of the brain as exercise is to the development of a muscle; and that interest is the condition of a lively attention. When in a school or lecture room the limit of close attention is reached, the lesson or lecture should close, for the educational process has already stopped. It is not only useless, but it is worse than useless, to go on when the class or audience refuses for any reason to attend. I, therefore, doubt the educational value of subjects which are not, and perhaps cannot be, made interesting.

Of course I do not claim that all selected studies can be made equally interesting, or that any one study can be made equally interesting to all pupils, even when the pupils are properly graded; but I do claim that a lively interest is necessary, and that educational progress is very nearly proportional to the strength of that interest.

But all educators do not agree with me here. A Harvard professor recently wrote as follows: "The practical aim of a general education is such training as shall enable a man to devote his faculties intently to matters which of themselves do not interest him. The very fact that the abstractions of mathematics must generally seem repellently lifeless, is part of the secret of their educational value." He praises the "elder education" which "through daily hours, throughout all their youthful years, compelled boys, in spite of every human reluctance, to fix their attention on matters which, of themselves, could never have held attention for five minutes together."*

This advocacy of ten or twelve years of uninteresting studies, none of which could hold the attention for five minutes unless they were forced upon the student—as the best preparation for dealing with the interesting matters of real life, such as earning one's bread, building a home, rearing a family, contributing to the common weal, and achieving the highest success—

*Professor Wendell, *North American Review*, September, 1904.

this remarkable doctrine is the product of our own age. No ancient or medieval teacher, so far as I am informed, ever promulgated or defended it. The credit or discredit of its authorship belongs to our own day and generation. On the other hand, that veteran and very sensible writer, John Locke, two hundred and fifty years ago said: "The great skill of a teacher is to get and keep the attention of his scholar. To attain this, he should make the child comprehend the usefulness of what he teaches him, and let him see, by what he has learned, that he can do something which he could not do before; something which gives him power and real advantage."

I join Professor Wendell in discounting the whims and fancies of children, and in his estimate of the value of an unintelligent choice of studies; but we must part company when he would force me to accept the doctrine that I must be careful not to make my mathematics and mechanics very interesting, lest their educational value be impaired. May I not refer this matter also to a section on education?

## FREE ELECTION OF STUDIES.

Closely related to the above is the great question of elective courses of study in our colleges. Personally, I am less concerned with this, since in the school or college of engineering with which I am connected, the curriculum is carefully laid down, and there is no election till the end of the freshman, and generally not till the end of the sophomore, year—and even then only a single election of a carefully prepared line of study is allowed. But I have been a more or less interested observer of the working of a free elective system elsewhere. I am not now going to discuss it, or to weigh it in the balance of experience. Such a discussion of its theory and practice would occupy a full paper before an educational section. Science teachers and scientific men are, or should be, deeply interested in this matter, for, if I mistake not, the rush for certain branches of science, and away from the traditional studies, has led in many cases to the calling of a halt in the freedom of election. My own conviction is that the pendulum has swung too far.

The number of required studies should be increased and the later years should be given to a group of subjects selected from a list of groups prearranged by the faculty. It is perhaps not quite safe to condemn a system which permits a student, having entered college on substantially the old requirements, to go through and graduate with honor, without giving during his entire college course a single hour to any one of the three corner-stones of the old curriculum of my college days: Latin, Greek and mathematics—but it certainly raises a question in the mind of every reader of educational history. Is there not a golden mean between predestination and free-will in the matter of studies and educational values?

## OTHER EDUCATIONAL QUESTIONS—ATHLETICS.

Never, since the days of Grecian games at Olympia, has physical culture, including field athletics, been so prominent a feature of student life as now. We can truthfully say that to-day athletics is the most conspicuous part of an academic education. Unquestionably the curriculum is out of balance, and a readjustment is necessary. The healthy, normal boy (and I may add, the healthy, normal girl) requires and enjoys vigorous exercise in the shape of games. While I advocate rational athletics, I deeply deplore semi-gladiatorial exhibitions which put the emphasis in the wrong places, and which mislead and demoralize the entire student-body. There has been a drift backward of late years towards a species of barbarism, which we had fancied we had outgrown. It becomes scientific men to restore—or better, to establish—a condition of educational equilibrium.

I cannot even mention all the matters of prime importance which would speedily come before an educational section. The organization and functions of boards of education are matters of the greatest moment at the present time, and I suspect they have a perennial interest. It is already on the program of one of your sections.

Some thirty years ago kindergartens were incorporated into the course of instruction of the public schools of St. Louis, and

later into the schools of many other cities. The constitution of the state of Missouri—very unwisely, I think—does not allow children under six years of age to attend any form of a public school; yet we shall all agree that the best kindergarten ages are the fifth and sixth years. Nevertheless, nearly every child in St. Louis for the last thirty years has attended kindergarten during his entire seventh year, taking up the primer for the first time upon entering the "first grade" when seven years old.

In spite of occasional protests and claims that valuable time is thereby wasted, the plan is fairly popular and there is no near prospect of change. The later progress of the relatively mature children in the first grade is remarkable, and many observant principals think that ultimately no time is lost. As for myself, my judgment is in suspense, and yet I have sent five children to the kindergarten. It is always difficult to compare what has been with what might have been, and with what would have been, had things been different. Suppose I refer this all-important matter to scientific educators.

## PHYSIOLOGICAL PSYCHOLOGY.

Perhaps the most valuable contribution to the science of education has come through a study of the laws which obtain in the growth and development of the brain, and the conditions under which that growth and development is most healthy and complete. There are times and seasons for the development of the mental and moral faculties as there are of the physical faculties. While such times and seasons are not precisely the same for all children, we find that all attempts at premature development are not only worthless, but are permanently injurious. Precocity is now regarded as a species of brain deformity. Plants and animals may be forced, and unusual and interesting results may be produced by forcing, but no one of us wishes a son or a daughter to be a prodigy in one direction as the cost of normal development in other directions.

The psychologists tell us that the brain cells develop as do other physical organs, not only through thought, but through

muscular activity and the exercise of our senses. Accordingly, a healthy and timely growth and development of the brain is to be promoted by an education involving a great variety of activities, skilfully adjusted as to quality and quantity to the mental and physical status of the child. I have often thought, when candidates for admission to Washington University present themselves, that, instead of asking them several sets of questions on a variety of somewhat conventional subjects, I would like to take off their skulls and brain coverings, and see how fully their primal brain cells were developed, and the extent to which the network of intercommunication between cells had been established and was in good working order. Such an examination would tell far more than any mere written examination. To be sure, I might find it difficult to read and interpret what would be written there, but the record would be there to the minutest particulars.

This branch of my subject outruns both my time and my ability. But there are experts, and they are veritable men of science, and they are most welcome to the companionship and fellowship of this association.

## MANUAL TRAINING.

Closely related with this of brain culture is the subject of manual training, which has recently gained a foothold in our scheme of rational education. Its nature and educational value are still under discussion. This relationship is well shown in a paragraph which I take from one whom I am always glad to quote.* Said he:

"In man, the size of the motor area in the brain depends far more on the complexity of the movements affected by a group of muscles, and on the fine coordination of these movements, than on the mere mass of the muscles involved. Physical energy implies a good motor brain area. The man of energy is a man of brains, no less really than the man of thought.

"Physiologists distinguish muscles as 'fundamental' and 'accessory.' The fundamental muscles are the large masses

*Professor Thomas M. Balliet, of the University of New York.

of muscles used in locomotion and in performing movements requiring strength rather than fine adjustments and delicate coordinations. They are, for the most part, the muscles which we have in common with the lower animals and which we have probably inherited from our forefathers who dwelt in trees. The accessory muscles are those which involve fine coordinations They are principally the muscles of the forearm and hand, and those of the vocal organs. Now it might be argued that manual training is not necessary for the development of the motor centers in the brain, on the ground that gymnastics and outdoor physical exercise are quite adequate to accomplish it. The answer to this objection is the fact that gymnastics and physical exercise in general appeal almost exclusively to the fundamental muscles and their brain centers, and rarely to the accessories. Nothing short of manual training will reach effectively the important brain cells governing the fine motor adjustments of the muscles of the hand, as nothing short of actual speaking and actual singing can ever effectively develop the equally important brain cells governing the muscles of the vocal organs. The motor cells of the brain controlling the muscles of the joints nearest the trunk develop first, and later, in regular order, those which control the muscles of the more distant joints. Education ought to follow this order of growth; it should avoid training the fingers to make finely coordinated movements at a period when nature has not yet got beyond developing brain cells to make the coarser adjustments of the shoulder and elbow joints. Physical training, which appeals to these more fundamental muscles of the proximal joints, should at first precede manual training, which appeals especially to the muscles of the forearm, hand and fingers."

We have in the above statement a scientific explanation of the educational value of manual training, so far as it relates to the growth and development of the brain.

As some of you know, I have had something to do with the introduction and defense of manual training as an educational feature. There was from the first no question of its economic value to the great mass of American boys, and largely for that

reason it met with favor among people who were more concerned with the work the boy would be given to do after his brain and hands had been developed, than with the means and activities by which the finest and most useful development of the whole boy could be secured.

A study of the whole field of education, classical and technical, led me, in 1879, to organize a school for boys of high-school age in which manual training should be combined with intellectual training; to put the liberal arts and the mechanic arts side by side in the same curriculum; to deal simultaneously with material forces and appliances and with spiritual forces and appliances; to cultivate not alone or chiefly the memory and the understanding, the eye to read and the mouth to speak, but the judgment and the executive faculties as well; to extend the humanities so as to include human interests and human activities as they exist now and here. Many wise and excellent educators had grave fears as to the result of the experiment. It was thought that the introduction of tools, machinery, materials, the theories of construction, and draughting, might not only break up the orderly program of the school, but they would lower its intellectual and moral tone. It is now known that all such fears were groundless. Manual training, when properly adapted to the boy's status of brain development, and when incorporated into the daily and weekly program with due regard to the other essential features, has proved to be a more valuable element in education than even the most sanguine advocate dared to expect. The moral, intellectual and economic fruit of this combination, as shown in the characters and careers of the boys who formed the first classes in the pioneer schools, is the best possible evidence of its value. The gloomy predictions made of its effect upon the pupils, and upon our American system of schools, have been forgotten, and early opponents are fast friends and enthusiastic advocates.

This is no place nor time for me to give an exposition of manual training; I have preached its gospel elsewhere and often. But I mention it as one of the important matters which must be carefully weighed and adjusted. We must defend it from frivolity on the one hand, and from misdi-

rection and undue emphasis on the other. At first it was suspected that our motives were sordid; that we were likely to degrade our schools, to teach narrow trades, and to turn out "mere mechanics" instead of educated men. On the other hand, a recent report of a Massachusetts commission (for whose membership I cherish high respect) regards the manual training movements as almost exclusively educational and not sufficiently industrial. I suppose the earlier and the later estimates are still held by many sincere and able teachers. One does not easily lay aside the convictions of a lifetime. The manual training movement stands inevitably as a criticism upon the system of education which came down the ages through the fathers to us, and naturally the latter stands on the defensive. It is also a standing reproof to the old wasteful, unscientific method of teaching to apprentices the theory and uses of tools. It is for educational science to justify the ways of progress which lays aside the idols of the past and erects new temples and opens new kingdoms. Of all the temples, none is finer, none is more glorious and none should be more scientifically planned and reared than that of education. While no section of this association can enforce the dictates of science, it would be helpful if we were able to establish these two things as true, viz.:

1. That usefulness does not impair educational values.

2. That a so-called culture-study like Latin may properly stand side by side with manual training in the curriculum.

We are all pleased (though perhaps surprised) when we learn that a man who reads blue-prints, and can make and use a diamond-point machine-tool, is also a linguist and at home in the calculus; and yet we are more than likely to assume that the boys who are studying the theory and use of tools have little need of literature; and that the student of the classics is wasting his time in a laboratory of the mechanic arts.

"What are these boys studying Latin for?" said an English visitor at the manual training school as he looked in upon a class reading Cæsar.

"What did you study Latin for?" was my illogical but American response.

"Why, I am a bachelor of arts!" was his prompt reply, with the air of one who had given a conclusive answer.

"Perhaps these boys will be bachelors of arts by and by," I added cheerfully.

"Then, what in the world are they in a manual training school for?" he exclaimed, with almost a sneer at my evident lack of acquaintance with the etiquette of educational values.

I tried to explain my theory of an all-around education—and my practice of "putting the whole boy to school"—but he would not be convinced. He could not see the propriety of mixing utility and tool dexterity with culture. Our visitors are not all Englishmen; yet I venture the estimate that fully one-half of the bachelors of arts who look through our study rooms and our work rooms have about the same prejudice as the Englishman had, though they do not so openly express it.

## THE NEW EDUCATION.

The evolution of the fully fledged technical school, or the technical department of the university, has taken place during the last half century, and yet its broad, stimulating, attractive features have a following which bids fair to double the attendance of college and university students. This does not mean that letters and polite learning are being neglected, but that a new constituency is eager for the new education. This new education, though it recognizes at all points a high order of usefulness, and contains little that is conventional, is only remotely professional. If ever its curriculum becomes narrow, it is quickly condemned by the best representatives of an education which combines utility with culture. No longer can the "Levites of culture," as Huxley calls them, claim to monopolize liberal education. The new education can be as liberal as the old, and both can be narrow. Fortunately, they flourish side by side, and the future shall choose the excellencies of each. An adequate science of twentieth-century education will evaluate the characteristics of each, and bring the wisdom of the past, not its foolishness, to nourish the wisdom of the future.

In conclusion, let us not fear to lay the foundations of the

science of education broad enough to carry and to advance our twentieth-century civilization. Let us not fear to strike out for ourselves when the age presents new demands. Progress is essential to life, as Browning says:

"What comes to perfection perishes."

I see nowhere, in either ancient or modern times, a people whose youths have been trained as our Americans should be trained. Neither Greece nor Rome with their pinnacles of culture resting on the barbarous foundation of human slavery, nor the blooded aristocracies of modern times, can teach us how to educate, train and adorn an American citizen. We must not expect all our students to rule, nor yet all to be ruled; to direct, nor yet to be directed; to employ, nor to be employed. They must be capable of all these things. No narrow, selfish aim, no prejudice of caste, no false claim of high culture which scorns service, must mislead the growing, expanding minds. Give them a generous, symmetrical training; open wide the avenues to usefulness, to happiness, to power; and this age of scientific progress and material wealth shall be also an age of high intellectual and social achievement.

SECTION A.

# Mathematics and Astronomy.

ADDRESS

BY

W. S. EICHELBERGER,

VICE-PRESIDENT AND CHAIRMAN OF SECTION A FOR 1906.

## *CLOCKS—ANCIENT AND MODERN.*

To those who have never had an opportunity to acquaint themselves with the history of the development of the modern clock, I wish to say that no attempt will be made to trace out that development. Time will not permit, as those familiar with the subject well know. I only wish to call to your attention a few points that I hope may be of general interest.

In Nepal, a small independent state situated on the north-eastern frontier of Hindustan, there is still practised what is one of the crudest and probably earliest methods of measuring time. A copper vessel with a small hole in the bottom floats on water, sinks and fills sixty times a day. Each time it fills, a gong, or ghari, is struck, in progressive numbers from dawn to noon; after noon the first gong struck indicates the number of gharis which remain of the day until sunset. Day is considered to begin when the tiles of a house can be counted or when the hairs on the back of a man's hand can be discerned against the sky. The day is divided into 60 gharis of 24 minutes each, each ghari into 60 palas and each pala into 60 bipalas.

Leaving India for Sumatra and stepping aboard a Malay proa we should there find, floating in a bucket of water, a cocoa-nut shell having a small perforation, through which the water by slow degrees finds its way into the interior. When the shell fills and sinks, the man on watch calls the time and sets it afloat again.

The gradual development through untold ages of the floating copper vessel has given us our finest astronomical clocks of to-day, and similarly the floating cocoanut shell may be considered the simplest form of a marine chronometer.

If now we visit the Chinese Empire we find in use there also the water clock, but instead of the water flowing into a vessel through a small hole in the bottom, it flows out of the hole. In attempting to calibrate such a vessel so that any given portion of the whole time required to empty it might be determined, it is at once noticed that when the vessel is nearly full the water flows out more rapidly than when it is nearly empty. The difficulty here presented is most easily overcome by keeping the vessel filled with water when the flow will be uniform, and catching the discharged water in a cylindrical vessel in which the surface of the water will rise equal distances in equal times. Chinese writers ascribe the invention of this instrument, called a clepsydra, to Hwang-ti, who lived more than twenty-five centuries before our era. About fourteen centuries later Duke Chau introduced a float upon the surface of the water in the final cylinder by means of which an indicator was made to travel over an adjacent scale as the water rose in the cylinder, thus allowing the indications of the instrument to be perceived at a greater distance.

These instruments that have just been described may be called artificial timekeepers, and are used primarily to subdivide the day, while the sundial of equal antiquity with the others may be called a natural timekeeper, as it gives a means of determining day after day a particular time of day, such as apparent noon.

The earliest mention of a sundial is found in Isaiah 38:8, in connection with the promise of the Lord to add fifteen years to the life of Hezekiah who lived about 2,600 years ago. "And this shall be a sign unto thee from the Lord, that the Lord will do this thing that he hath spoken; behold, I will bring again the shadow of the degrees, which is gone down in the sundial of Ahaz, ten degrees backward. So the sun returned ten degrees, by which degrees it was gone down."

Of the nature of this sundial nothing is said, nor is there

found any description of such an instrument until 350 years later, when we find the sundial of the Chaldean priest Berosus, who lived in the time of Alexander the Great and his immediate successors.

This consisted of a hollow hemisphere placed with its rim perfectly horizontal, and having a bead fixed at its center. So long as the sun remained above the horizon the shadow of the bead would fall on the inside of the hemisphere, and the path of the shadow during the day would be approximately a circular arc. This arc, divided into twelve equal parts, determined twelve equal intervals of time for that day. Now supposing this were done at the time of the solstices and equinoxes, and on as many intermediate days as might be considered sufficient, and then curve lines drawn through the corresponding points of division of the different arcs, the shadow of the bead falling on one of these curve lines would mark a division of time for that day, and thus we should have a sundial which would divide each period of daylight into twelve equal parts. These equal parts were called *temporary hours;* and since the duration of daylight varies from day to day, the temporary hours of one day would differ in length from those of another. Dials of this form were still used by the Arabians a thousand years ago, and, about 1750, four such were found in Italy.

The introduction of the sundial into Greece is generally fixed by historians in the latter part of the sixth century B. C. At that time the instrument seems to have been a very crude one, consisting merely of a pillar without any graduated dial by means of which the day could be divided into a number of equal parts. The length of the shadow determined the time for certain regular daily duties, as a shadow six feet long might indicate the time for bathing, and one twelve feet long that for supper.

As civilization advanced and the needs of the people required more accurate measures of time, the sundial was developed. We have already mentioned the sundial of Berosus, about 350 B. C., by means of which each day from sunrise to sunset was divided into twelve equal parts; that is, provided the sun was visible all day long.

As the sundial could not be used indoors or on cloudy days, as soon as the Grecian life became complex enough to need a timepiece under such circumstances, this demand was met by the clepsydra. The time of its introduction is not definitely known, but the familiar references of Aristophanes show its use to have been common about 430 B. C., while no mention is made of it by Herodotus, whose history ends fifty years earlier.

A passage in Aristotle gives some idea of the early form of the clepsydra: it was a spherical bottle with a minute opening at the bottom and a short neck at the top into which the water was poured, and by closing which the flow of the water could be stopped. This form of clepsydra became a necessary adjunct of all courts of justice, and the number of gallons of water that a lawyer was allowed for his speech gave some indication of the importance of the trial. In fact, the word ὕδωρ became a synonym for time. We find Demosthenes charging his opponent with talking "in my water;" and on another occasion he shows the value he attached to the time allotted him by turning to the officer, when interrupted, with a peremptory "You there! stop the water!" reminding one of the "take out time" of our modern football contests.

The first timepiece of the Romans seems to have been the watchman, who, from the Senate House, called forth noon as soon as he caught sight of the sun between the Rostra and the Græco-Statis. From the same point he watched the declining sun and proclaimed its disappearance. This custom was probably instituted towards the close of the fifth century B. C. According to Pliny the first sundial was set up in Rome about 290 B. C. About thirty years later Consul Valerius Messala erected at Rome a sundial which was captured at Catania in Sicily. This instrument was not a mere gnomen such as was introduced three centuries earlier into Greece, but was the result of Grecian science and genius, constructed for a particular latitude, that of Catania, 5° south of Rome. For a hundred years this sundial supplied the needs of the Romans for a timepiece, although it was constantly in error. Finally, in 164 B. C., Marcius Phillippus set up near the dial of Catania, one con-

structed for the latitude of Rome, and Rome then possessed her first accurate timepiece; and during the time of Plautus the use of sundials became common, as is evidenced by the following quotation:

> When I was young, no time-piece Rome supplied,
> But every fellow had his own—inside;
> A trusty horologe, that—rain or shine—
> Ne'er failed to warn him of the hour—to dine,
> *Then* sturdy Romans sauntered through the Forum,
> Fat, hale, content; for trouble ne'er came o'er them,
> But *now* these cursed dials show their faces,
> All over Rome in streets and public places;
> And men, to know the hour, the cold stone question,
> That has no heart, no stomach, no digestion,
> They watch the creeping shadows—daily thinner—
> Shadows themselves, impatient for their dinner.
> Give me the good old time-piece, if you please,
> Confound the villain that invented these!

As in Greece so in Rome, the clepsydra followed in the wake of the sundial, and as in the case of the sundial, Grecian science and genius had by this time produced a much more perfect instrument than that first used by the Greeks.

In describing the sundial of Berosus, I stated that by it the day was divided from sunrise to sunset into twelve parts, varying in lengths from day to day, called temporary hours. If now the clepsydra and the sundial were to read alike, it was necessary that the hours recorded by the clepsydra should also change from day to day. Various devices were adopted to accomplish this. Further, as the clepsydra could be used throughout the entire day and night, it was necessary to have it record hours of a different length at night from what it did in the day, as each night, *i. e.*, from sunset to sunrise, was divided into twelve hours as well as each day.

Fig. 1 represents an early form of the clepsydra. It consists of an inverted cone *A*, with a small aperture at its vertex. The water is supplied through the pipe *H* and is prevented from rising above a fixed level in *A* by the waste pipe *I*, which carries off the superfluous water. Thus there will be a uniform flow of water from the vertex of the cone into the cylindrical vessel

and the cork $F$ will rise uniformly, communicating its motion through the rod $E$ to the hand $G$, which indicates the hours on the dial. In order to produce a change in the rate of flow of the water from the conical vessel, as is necessary in having the hand indicate hours of different length from day to day, a solid cone $B$, similar to $A$, was plunged into the hollow one, and its position for any given day or night was indicated by the coincidence of a particular one of the adjusting marks on the stem $D$ with the top cross-piece of the frame $C$.

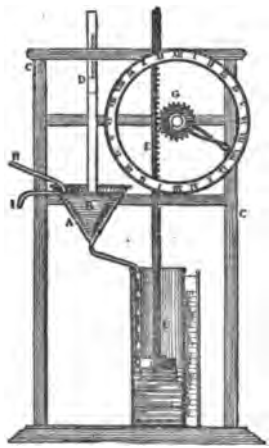


FIG. 1. Early Form of Clepsydra.

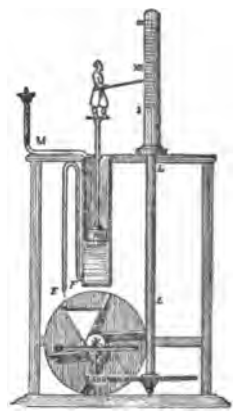


FIG. 2. Clepsydra of Ctesibius.

A later form of clepsydra, attributed to Ctesibius, who lived during the latter part of the third century B. C., is shown in Fig. 2. $A$ is the end of a tube over which an image stands, which is connected with a full reservoir, and from the eyes of which, considered as invariable apertures, the water continually flows or drops in a regulated manner into it; this tube conveys the water into the top of the cylindrical vessel $BCDF$, which gradually fills, the cork $D$, with its attached pillar $C$, rising at the same time. On the top of this pillar is an image holding an index which points to the divisions on the large column above. Now when the water rises in the cylindrical vessel it also rises in the small tube $FB$, which constitutes one leg of a

syphon; consequently, when the small tube fills and the index has mounted to the top of the large column, the water flows over the bent part *B* of the syphon and the vessel is emptied into one of the six troughs of the waterwheel *K*, which is thus turned one-sixth of a revolution, and the column, by means of the gearing shown in the figure, 1/365 of a revolution, during which time the image falls with its index to the bottom of the column, to be ready for the next day. There are ruled around the large column twenty-five lines properly sloped with respect to each other, so that the index may indicate the hour on any day of the year.

For the next fifteen centuries or more after the introduction of this clepsydra of Ctesibius, sundials and clepsydras were the timekeepers of mankind. These were then gradually supplanted by weight clocks.

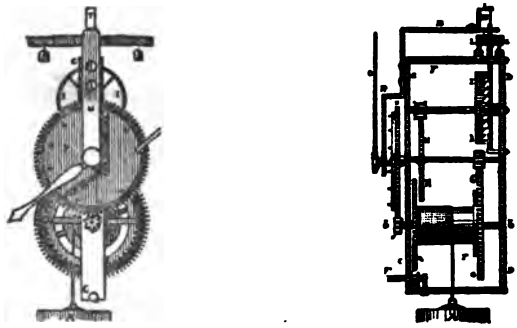
I am not able to give the date of the manufacture of the first clock composed of an assemblage of wheels actuated by a suspended gravitating body and controlled by a regulator of some determined shape and dimensions, *i. e.*, a regulated machine for measuring time without the assistance of water.

There may be seen at the South Kensington Museum an old clock movement, now controlled by a pendulum, which was removed about seventy years ago from a clock in Wells Cathedral and which is said to have been built by Peter Lightfoot, about 1335, for the church of Glastonbury Abbey, from which it was removed to Wells Cathedral in the reign of Henry VIII, where, I believe, the dial and its accessories may now be seen. In addition to indicating the time, this clock was intended to indicate the age of the moon and to show its phase. Also it caused a man to strike the quarter hours with his feet on two little bells, and the hours on another bell before him with a battle-axe that is in his hand. It also set in motion four equestrian knights equipped for a tournament. If the date given for the clock is correct the figures operated in connection with it are hardly the original ones. One of the knights is painted in the civil costume of the seventeenth century.

About 1360 there was erected in the tower of the palace of Charles V of France a clock constructed by Henry de Vick, of

Würtemberg. This clock was made for the simple purpose of telling the time of day and was not expected to perform the numerous feats that were so frequently required of clocks in earlier days, and may be taken as a type of the earliest clock movements.

From Fig. 3, giving both a front and a side view, the operation of the clock may be clearly understood. The motion of the falling weight *A* is transmitted by means of the wheels *G*, *e*, *H* and *g* to the wheel *I;* this last wheel, by giving the pallets or short levers, *h*, *i*, each a push alternately by two teeth, at oppo-



Front view. Side view.

FIG. 3. Ancient Clock by Henry de Vick.

site sides of its circumference, and moving in opposite directions, one forward and the other backward, gives a vibratory motion to the vertical arbor *K*, and as the regulator or balance was fixed on this arbor, it was thus made to vibrate backwards and forwards at every push of the escapement wheel upon the pallets, the period of the vibration being regulated by the position of the small weights *m*, *m* on its arms. Thus the whole duration of a vibration was the measure of time, and the wheels and pinions were employed first to transmit the maintaining power to the balance, and secondly to number the vibrations and indicate them in visible form by a hand *O* on a dial plate. Fig. 4 gives a view of the escapement wheel looking from above. The pallets were placed at about 90° from each other on the arbor or verge of the balance, so that when one of them was

parting with its tooth of the escapement wheel, the other was in a situation to receive the opposite one immediately, but the motion of the verge will not be at once reversed. The escape wheel will recoil until the impetus of the balance is exhausted.

The substitution of the main spring for a large heavy body as a first mover constituted a second era in modern horology, from which we may date the origin of the fusee, or mechanism for equalizing the variable power of a coiled spring.

While the date at which the first portable clock was made may not be definitely stated, it was certainly as early as 1525, as the Society of Antiquaries in England has in its possession one made in that year by Jacob Zech at Prague, the inventor of the fusee. Its construction differs materially from that of De Vick's clock only in that it has a spiral spring with a fusee instead of the driving weight.

Such was the state of clockwork when Galileo, the celebrated philosopher and mathematician, while watching the vibrations

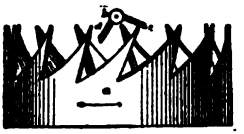


FIG. 4. View of de Vick's Escapement Wheel from Above.

of the great bronze lamp swinging from the roof of the cathedral of Pisa in 1583 observed that, whatever the range of its oscillations, they were invariably executed in equal times. Because of this isochronal property of a vibrating suspended body the pendulum was introduced as the regulator of clockwork, thus inaugurating the third era in the development of the modern clock.

The honor of being the first to apply a pendulum as a regulator of clockwork is claimed for several clockmakers.

The earliest of these is, I believe, Richard Harris, who is said to have made a pendulum clock for St. Paul's Church, Covent Garden, in 1641. Vincent Galileo claims to have applied his father's discovery to the construction of a pendulum clock in 1649, but does not seem to have made the fact public until

after Huyghens in 1657 presented to the States of Holland a clock controlled by a pendulum, claiming for himself the invention of this form of control. Certain it is that Huyghens gave much study to the mathematical theory of the pendulum, and proved that in order that pendulum vibrations of different lengths should be strictly isochronal, the pendulum should vibrate between cycloidal checks. Such an arrangement he introduced into his clock of 1657, which also contained the famous Huyghens loop in connection with the winding apparatus.

With the verge escapement, Fig. 4, the one in use when the pendulum was applied to clockwork, and which required a long arc of vibration for the escapement of the escapement wheel, the deviation of the circular arc described by an ordinary pendulum from the theoretical cycloidal arc was, of necessity, taken into account.* With the introduction of the anchor or recoil escapement, Fig. 5, invented by Dr. Hooke in about 1675, the long swing of the pendulum was obviated and the cycloidal cheeks were found to be more detrimental than advantageous.

The expansion of metals by heat has been known ever since the middle of the seventeenth century, and early in the eighteenth George Graham set himself the task of making a clock pendulum such that the distance between the center of oscillation and the center of suspension would be independent of the temperature. I quote from his paper "A Contrivance to Avoid Irregularities in a Clock's Motion by the Action of Heat and Cold upon the Pendulum," communicated to the Royal Society in 1726:

"Whereas several who have been curious in measuring time have taken notice that the vibrations of a pendulum are slower in summer than in winter, and have very justly supposed this alteration has proceeded from a change of length in the pendulum itself, by the influence of heat and cold upon it, in the different seasons of the year; with a view, therefore, of correcting, in some degree, this defect of the pendulum, I made several trials, about the year 1715, to discover whether there was any considerable difference of expansion between brass, steel, iron, copper, silver, etc., when exposed to the same degree of heat

as nearly as I could determine, conceiving it would not be very difficult, by making use of two sorts of metals, differing considerably in their degrees of expansion and contraction, to remedy, in great measure, the irregularities to which common pendulums are subject. But although it is easily discoverable that all these metals suffer a sensible alteration of their dimensions by heat and cold, yet I found their differences in quantity from one another were so small, as gave me no hopes of succeeding this way, and made me leave off prosecuting this affair any further at that time. In the beginning of December, 1721, having occasion for an exact level, besides other materials I made trial of, quicksilver was one; which, although I found it was by no means proper for a level, yet the extraordinary degree of expansion that I observed in it when placed near the fire, beyond what I had conceived to be in so dense a fluid, immediately suggested to me the use that might be made of it by applying it to a pendulum. In a few days after I made the experiment, but with much too long a column of quicksilver, the clock going slower with an increase of cold, contrary to the common pendulum; however, it was a great confirmation of the advantage to be expected from it, since it was easy to shorten the column in any degree required."

As his first jar was too long, so his second was too short, but by June 9, 1722, he was ready to test the running of his mercury pendulum clock with one regulated by an uncompensated pendulum. He says:

"For the first year I wrote down every day the difference between the two clocks, with the height of the thermometer, not omitting the transits of the stars as often as it was clear. The result of all the observations was this, that the irregularity of the clock with the quicksilver pendulum, compared with the transits of the stars, exceeded not, when greatest, a sixth part of that of the other clock with the common pendulum; but for the greatest part of the year, not above an eighth or ninth part, and even this quantity would have been lessened had the pillar of mercury been a little shorter, for it differed a little the contrary way from the other clock, going faster with heat, and

slower with cold; but I made no alteration in length to avoid an interruption of the observations."

A few years afterward John Harrison brought out his gridiron pendulum composed of four brass and five steel rods, so constructed that the expansion of the steel rods tended to lower the pendulum bob while the expansion of the brass one tended to raise it.

Another form of compensated pendulum that has found favor is the zinc-tube pendulum, in which the zinc tube surrounds a rod of steel and is itself surrounded by a tube of steel. Here the zinc tube fulfils the purpose of the brass rods in the gridiron pendulum. At present at least one firm of clock manufacturers is using invar or nickel steel for its pendulum rods.

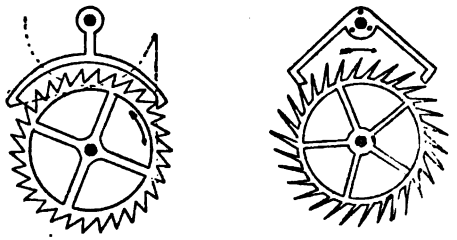
Attempts have also been made to compensate a pendulum to avoid changes in the rate due to changes of the barometer. At Greenwich this is accomplished by attaching a magnet to the end of the pendulum and causing a second magnet supported below the pendulum to approach or recede from the pendulum with changes of the barometer. This second magnet increases the acceleration due to gravity to a greater or less degree as it approaches or recedes from the pendulum.

The most satisfactory way, however, of freeing a clock rate from variations due to changes of temperature and pressure is to enclose the clock in an air-tight glass case kept in a room of constant temperature. A number of observatories now keep their standard clocks under such conditions.

Another improvement in the manufacture of clocks was accomplished by Graham in the introduction of the dead-beat escapement.

In Fig. 5 are shown both the anchor or recoil escapement and the dead-beat escapement. In the first, shown on the left, the pendulum moving to the left has just escaped a tooth at the left-hand pallet and allowed a tooth to fall on the right-hand one. The pendulum, however, still continues its swing to the left, and in consequence the pallet pushes the wheel back, thus causing the recoil that gives the name to the escapement. It is only after the pendulum comes to rest and begins

its excursion the other way that it gets any assistance from the wheel, and the difference between the forward motion of the wheel and its recoil forms the impulse. In the right-hand figure, the pendulum moving to the right has just escaped a tooth from the right-hand pallet while another has fallen upon the left-hand one. As the pendulum continues its motion towards the right, the left-hand pallet slides over the point of the tooth, but there is no recoil, as the "dead" face, as it is called, is the arc of a circle whose center is the point about which the anchor turns. As the pendulum returns towards the left, the tooth traverses the "dead" face in the opposite direction, and immediately upon leaving this face it passes to



Anchor or Recoil Escapement. Dead-beat Escapement.

FIG. 5.

the "impulse" face, and while passing along this face gives the impulse to the pendulum.

The great advantage of the dead-beat escapement over the anchor or recoil type is that, although a slight increase of force on the escapement wheel increases the arc of the pendulum, it does not sensibly increase the time, while the time does sensibly increase with the recoil escapement.

At about this time also, Mudge introduced the gravity escapement. With all the previous escapements the impulse was given to the pendulum by the driving weight acting through the train so that any irregularities in the train would cause a variation in the impulse. With the gravity escapement a weight is raised by the train and the falling of this weight gives the impulse to the pendulum. We thus have a uniform impulse at each oscillation due to the falling of a weight through a fixed

distance. Simple and elegant as is this theory, the application of it gave a great deal of trouble and all gravity escapements were regarded with suspicion, as having a tendency to trip, until Mr. Denison designed the double three-leg one for the great clock at the Houses of Parliament about fifty years ago. Incidentally, it might be mentioned that this Westminster clock has turned out to be the finest timekeeper of any public clock in the world. The original specifications required that the clock should be guaranteed to perform within a margin of a minute a week, which caused the leading clockmakers of England to decline to bid for the work. However, under Mr. Denison's supervision the clock was built by Mr. Dent, and from reports of the Astronomer Royal, who receives at Greenwich two signals a day from this clock, sent automatically, its error is rarely over a second a week.

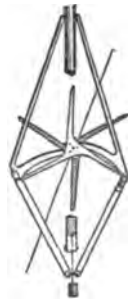


FIG. 6. Denison Gravity Escapement.

The Denison gravity escapement is shown in Fig. 6. This escapement consists of two gravity-impulse pallets pivoted as nearly as possible in a line with the bending point of the pendulum spring and touching the pendulum near the bottom of the figure. The locking wheel is made up of two thin plates having three long teeth or "legs" each. These two plates are squared on the arbor a little distance apart, one on each side of the pallets. Between them are three pins which lift the pallets. In the figure, one of the front legs is resting on a block screwed to the front of the right-hand pallet. There is a similar block screwed to the back of the left-hand pallet for the legs of the

back-plate, which is shaded in the figure, to lock upon. Projecting inward from each of the pallets is an arm. The tip of the one on the right-hand pallet is just in contact with one of the pins which has lifted the pallet to the position shown. The pendulum is traveling in the direction indicated by the arrow, and the left-hand pallet has just given impulse. The pendulum rod in its swing will push the right-hand pallet far enough for the leg of the front locking plate, which is now resting on the block, to escape. Directly it escapes, the left-hand pallet is lifted free of the pendulum rod by the lowest of the three pins. After the locking wheel has passed through 60°, a leg of the back locking plate is caught by the locking block on the left-hand pallet. As the three-leaved pinion always lifts the pallets the same distance, the pallets in returning give a constant impulse to the pendulum.

About fifteen or twenty years ago the Rieflers, clockmakers of Munich, introduced into their clocks an escapement in which the impulse is communicated to the pendulum through the suspension spring. The pendulum is supported by a locking frame to which is attached the anchor carrying the pallets which are acted upon by the escapement wheel. Just after the pendulum has passed through its vertical position, the escapement wheel, when released, gives to the supporting frame of the pendulum suspension spring a slight tilt in the opposite direction from that in which the pendulum is moving, thus increasing the tension of the spring due to the swing of the pendulum to one side.

In the next few minutes I wish to consider the accuracy with which our astronomical clocks perform their function.

The earliest star catalogue of precision is that of Bradley, and the observations upon which it is based were made about a third of a century after the introduction of the compensated pendulum. In discussing the performance of his clock, I have used the adopted rates as given by Auwers in his rereduction of Bradley. The monthly means of the rates from July, 1758, to July, 1759, were taken and the difference of each rate from its monthly mean. Then the mean of these differences without regard to sign was taken for each month.

## VARIATION OF DAILY RATE OF THREE GREENWICH SIDEREAL CLOCKS.

| Bradley's clock. | | | Sidereal stand, "Hardy." | | | Sidereal stand, "Dent." | | |
|---|---|---|---|---|---|---|---|---|
| Date. | Daily rate. | Mean residual. | Date. | Daily rate. | Mean residual. | Date. | Daily rate. | Mean residual. |
| 1758. | s. | s. | 1850. | s. | s. | 1900. | s. | s. |
| July | −0.086 | 0.060 | January | +0.666 | 0.269 | January | +0.280 | 0.035 |
| August | +0.012 | 0.079 | February | +0.857 | 0.162 | February | +0.196 | 0.041 |
| September | −0.012 | 0.077 | March | +0.930 | 0.117 | March | +0.170 | 0.038 |
| October | −0.130 | 0.166 | April | +1.154 | 0.257 | April | +0.134 | 0.027 |
| November | −0.094 | 0.127 | May | +1.607 | 0.105 | May | +0.078 | 0.028 |
| December | −0.190 | 0.096 | June | +1.372 | 0.117 | June | +0.022 | 0.045 |
| 1759. | | | | | | | | |
| January | −0.264 | 0.106 | July | +1.058 | 0.202 | July | −0.096 | 0.039 |
| February | −0.343 | 0.072 | August | +0.821 | 0.104 | August | −0.245 | 0.053 |
| March | −0.449 | 0.108 | September | +1.003 | 0.087 | September | −0.381 | 0.056 |
| April | −0.310 | 0.125 | October | +1.049 | 0.120 | October | −0.549 | 0.048 |
| May | −0.322 | 0.127 | November | +1.232 | 0.063 | November | −0.522 | 0.161 |
| June | −0.439 | 0.086 | December | +1.389 | 0.187 | December | −0.259 | 0.036 |
| Mean | | 0.102 | Mean | | 0.149 | Mean | | 0.051 |

The rates of two other clocks of the Greenwich Observatory were likewise discussed, the standard clock for the year 1850 and that for 1900, the adopted daily rates as published in the annual volumes being used. The first of these was kept in the observing room and thereby subjected to large variations of temperature, while the second, made in 1871 by E. Dent and Company, was fixed to the north wall of the magnetic basement, as in this apartment the temperature is kept nearly uniform. The pendulum of this latter clock is provided with barometric as well as thermometric composition.

I sought to make a similar comparison for the clocks of the other large observatories, but soon found that the information concerning the performance of the various clocks was given in such a form that it was in almost every case either impossible or extremely laborious to secure the desired result. However, there are two well-known clocks which should be mentioned in this connection, and in conclusion I will give some hitherto unpublished data concerning the clock with which I have been working during the past three years.

Probably no clock has had its rate more thoroughly discussed than Hohwü No. 17, the standard clock of the observatory at Leiden.

It was set up in the transit room in 1861 and in December, 1898, was removed to the large hall of the observatory, where, enclosed in two wooden cases, it was placed in a niche cut in the pier of the ten-inch refractor. To further guard against sudden changes of temperature the niche is closed by a glass door. At the meeting of the Royal Academy of Sciences at Amsterdam, held September 27, 1902, Dr. E. F. van de Sande Bakhuyzen submitted the following formula as the best representation of the daily rate of the clock:

$$\begin{aligned}\text{Daily rate} = &- 0^s.173 + 0^s.0157\,(h-760^{mm}) \\ &- 0^s.0253\,(t-10^\circ) + 0^s.00074\,(t-10^\circ)^2 \\ &+ 0^s.0465 \cos 2\pi\,(T-\text{May } 3)/365\end{aligned}$$

and gave the result of a comparison of the observed daily rates 1899–1902, the average interval of time for each rate being six

days, with those computed by means of the above formula. I find during the year 1900 the mean of these differences is $0^s.028$ and the largest difference is $0^s.071$.

About 1867 F. Tiede installed at the Berlin Observatory a weight-driven clock enclosed in an air-tight case. The original escapement was replaced in 1876 by a gravity escapement and the clock has continued to give satisfaction, certainly up until 1902, when it was dismounted for cleaning. The only published rates that I have been able to secure are those during twelve weeks in 1877–8. During this period the average deviation of the observed daily rates, the average interval for each rate being six days, from the mean daily rate for the entire period is $0^s.030$.

In connection with the publication of these rates* the statement is made that for weeks at a time this mean deviation will not exceed $0^s.02$.

DAILY RATE OF RIEFLER SIDEREAL CLOCK No. 70.

| Date. | Daily rate. | Mean barometer. | Mean temp. | Computed rate. | O–C. |
|---|---|---|---|---|---|
| 1904. | s. | mm. | ° | s. | s. |
| Feb. 8–11 | +0.019 | 631.0 | 28.3 C | +0.009 | +0.010 |
| 11–15 | −0.014 | 631.5 | 28.5 | −0.006 | −0.008 |
| 15–20 | +0.005 | 631.5 | 28.3 | −0.002 | +0.007 |
| Mar. 1–4 | −0.026 | 631.0 | 28.2 | −0.012 | −0.014 |
| 4–9 | −0.010 | 631.0 | 28.2 | −0.016 | +0.006 |
| 9–16 | −0.022 | 631.5 | 28.1 | −0.018 | −0.004 |
| 16–18 | −0.043 | 631.0 | 28.1 | −0.022 | −0.021 |
| 18–22 | −0.022 | 631.0 | 28.0 | −0.021 | −0.001 |
| 22–25 | −0.029 | 631.0 | 28.0 | −0.024 | −0.005 |
| 25–28 | +0.002 | 631.0 | 27.7 | −0.014 | +0.016 |
| 28–34 | −0.007 | 631.0 | 27.7 | −0.018 | +0.011 |
| Apr. 3–5 | +0.017 | 631.0 | 27.4 | −0.009 | +0.026 |
| 5–13 | +0.002 | 631.0 | 26.9 | +0.014 | −0.012 |
| 13–16 | +0.026 | 631.0 | 26.5 | +0.021 | +0.005 |
| 16–19 | +0.034 | 631.0 | 26.3 | +0.027 | +0.007 |
| 19–22 | +0.002 | 631.0 | 26.4 | +0.020 | −0.018 |
| 22–31 | +0.029 | 631.0 | 25.0 | +0.077 | −0.048 |
| May 1–4 | +0.113 | 631.5 | 24.3 | +0.103 | +0.010 |
| 4–7 | +0.082 | 631.0 | 24.1 | +0.109 | −0.027 |
| 7–12 | +0.161 | 631.0 | 24.0 | +0.109 | +0.052 |
| | | | | Mean.. | ±0.015 |

*A. N. Nr. 2184.

In 1903 there was installed at the Naval Observatory one of Riefler's clocks, No. 70, with a nickel-steel pendulum, the impulse being communicated to the pendulum through the suspension spring. This clock was enclosed in an air-tight glass case and was mounted in a vault where the temperature was artificially controlled. The definitive rates have been determined from September, 1903, to May, 1904, but, unfortunately, during this entire period we were unable to prevent the glass case leaking and there was a variation of temperature in the vault of about 5° C. However, from the first of February to the middle of May the pressure was kept nearly constant by reducing it each day by means of an air pump by from 1 to 2 millimeters. During this period the following results were obtained:

The formula from which the computed rate is obtained,

$$\text{Daily rate} = + 0^s.0161 - 0^s.00103\,(T-\text{Mar. } 29.0) - 0^s.0456\,(t-27^\circ.0)$$

is the result of a least square solution of the twenty observed rates.

Collecting together the results given above, we have:

MEAN DEVIATION OF DAILY CLOCK RATE.

| Clock. | Date. | Mean deviation. |
|---|---|---|
| Bradley | 1759 | 0.102 |
| Greenwich Observatory | 1850 | 0.149 |
| Greenwich Observatory | 1900 | 0.051 |
| Berlin Observatory | 1877 | 0.02–0.03 |
| Leiden Observatory | 1900 | 0.028 |
| U. S. Naval Observatory | 1904 | 0.015 |

In considering this table I hope the particular method by which each of the numbers given was obtained will be remembered. The reason for using different methods has already been given. If the rates of the first three clocks had been

treated in a manner similar to that used in the last three cases, the numbers given might have been slightly smaller, and if the period under consideration with the Berlin and Washington clocks had been longer the two corresponding residuals might have been slightly larger.

## PAPERS READ.

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THE RATIONAL BASIS OF MATHEMATICAL PEDAGOGY. BY PROFESSOR S. E. SLOCUM, UNIVERSITY OF CINCINNATI.

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PHOTOGRAPHIC OBSERVATIONS OF THE MILKY WAY. BY PROFESSOR E. E. BARNARD, YERKES OBSERVATORY.

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THE TENTH SATELLITE OF SATURN. BY PROFESSOR W. H. PICKERING, HARVARD UNIVERSITY.

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ON THE LAW OF GRAVITATION IN THE BINARY SYSTEMS. BY DR. F. L. GRIFFIN, WILLIAMS COLLEGE.

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LATITUDE TERMS OF LONG PERIOD. BY PROFESSOR C. L. DOOLITTLE.

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AN EXAMINATION OF THE RESULTS OF SEVEN YEARS' OBSERVATION WITH THE ZENITH TELESCOPE OF THE FLOWER OBSERVATORY FOR LATITUDE TERMS OF LONG PERIOD. BY PROFESSOR C. L. DOOLITTLE, UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

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A PRELIMINARY REPORT ON A SOLAR ROTATIVE PERIOD INVESTIGATION. BY MR. PHILIP FOX, YERKES OBSERVATORY, WILLIAMS BAY, WIS.

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THE RETROGRADE MOTION OF PHŒBE. BY MR. A. O. GRANGER, PHILADELPHIA, PA. (Read by title.)

THE SECT-CARRIER AND THE SET-SECT. By PROFESSOR G. B. HALSTED, STATE NORMAL COLLEGE, GREELEY, COLO.

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ON A FUNDAMENTAL THEOREM OF WEIERSTRASS BY MEANS OF WHICH THE THEORY OF ELLIPTIC FUNCTIONS MAY BE ESTABLISHED. By PROFESSOR HARRIS HANCOCK, UNIVERSITY OF CINCINNATI, CINCINNATI, O.

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DYNAMICAL TRAJECTORIES. By DR. EDWARD KASNER, COLUMBIA UNIVERSITY, NEW YORK CITY.

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THE STREAM FUNCTION FOR A STRAIGHT CHANNEL WITH A CIRCULAR ISLAND. By JAMES MCMAHON, CORNELL UNIVERSITY, ITHACA, N. Y.

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PRELIMINARY WAVE-LENGTHS OF FLASH SPECTRA TAKEN IN SPAIN, AUGUST 30, 1905. By Dr. S. A. MITCHELL, COLUMBIA UNIVERSITY, NEW YORK CITY.

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ON THE MINIMUM NUMBER OF OPERATORS WHOSE ORDERS EXCEED TWO IN ANY FINITE GROUP. By Dr. G. A. MILLER, UNIVERSITY OF ILLINOIS, URBANA, ILL.

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RESULTS OF PHYSICAL OBSERVATIONS ON THE SATURNIAN SYSTEM WITH THE 18-INCH CLARK REFRACTOR. By PROFESSOR DAVID TODD, AMHERST COLLEGE, AMHERST, MASS. (Presented by title.)

SECTION B.

# PHYSICS.

ADDRESS

BY

# HENRY CREW,

VICE-PRESIDENT AND CHAIRMAN OF SECTION B FOR 1906.

## *FACT AND THEORY IN SPECTROSCOPY.*

Before passing to some present problems in physics, let us pause a moment to consider the losses which our science has sustained since the last annual meeting.

The life and work of Professor Langley, who died on the twenty-seventh of February last, will long continue to form an important chapter in the history of astrophysics. To the study of this science he brought rare skill, perseverance and clearness of purpose. Among his most important contributions is to be mentioned his epoch-making determination of the distribution of energy through the spectra of various sources, including especially the sun, moon and firefly. His measurement of the lifting power of an aeroplane driven at a definite angle with a definite speed, his exquisite discussion of the "Internal Work of the Wind" with its accompanying explanation of soaring, and his still later achievement of actual flight, are matters which have perhaps only recently received fair appreciation. The recent performance of the Wright brothers in Ohio and the flight of Santos Dumont in a "manned" machine are but two events in the logical series which Professor Langley did much to initiate.

On the nineteenth of April, 1906, occurred a great tragedy. Nothing in the behavior of that remarkable element which he helped to discover can be considered more unexpected or more inexplicable than the death of Professor Pierre Curie.

The manner in which the clew given by uranium rays was taken up and followed out with persistent endeavor, clearness of vision, simplicity of life and modesty of character, has been rarely paralleled in the history of physics.

Our admiration for his scholarship and for his generous chivalric nature is united with a keen sense of loss to science and a warm sympathy for his brilliant and loyal comrade.

On the fifth of July last, Germany and the rest of the world suffered a deplorable and inexplicable loss in the death of Professor Paul Drude. Brilliant and numerous as his achievements were, it is difficult to believe that his work was more than half done. Perhaps no better illustration of his genius can be found than in the beautiful manner in which he has quantitatively connected the subjects of thermal and electric conductions, on the basis of the electron theory; while his two splendid volumes have rendered all students of physics his debtors.

The death of Boltzmann, two months later, was an equally great mystery. The most valuable work of this remarkable and somewhat bizarre character undoubtedly lies in the field of the kinetic theory of gases.

His treatise on this subject constitutes for me—I confess it freely, but sadly—a sealed volume. Were I to attempt to convey to you any idea of its importance I should feel, only in a much truer sense, what Boltzmann himself expresses in the preface of his wonderfully lucid exposition of Maxwell's electromagnetic theory, when he quotes from "Faust."

> "So soll ich denn mit saurem Schweiss,
> Euch lehren was ich selbst nicht weiss."

Boltzmann's two visits to America, one in 1898 and one in 1904, were full of interest for many of the members of this section. Suffice it to say that some of his colleagues have expressed the opinion that since the death of Helmholtz, Boltzmann has been the leading physicist of Germany.

I beg now to call your attention to a matter which seems to me somewhat intimately connected with spectroscopic progress. And one can perhaps do this most simply by first offering a definition of spectroscopy; secondly, stating what may be con-

sidered the fundamental facts of the science; and, thirdly, considering to what extent these facts—for one hesitates even yet to call them "principles"—are explained by any general theory of the subject.

Any explanation of light which is general and satisfactory may be said to include at least two chapters, namely, one which shall explain the transmission of radiation and another which shall treat of the origin or production of radiation. The first chapter treats of the electromagnetic ether; the second treats of matter which is at once "the source and recipient of radiation."

It was in the autumn of 1888 that the experiments of Hertz in a certain sense closed the chapter on the transmission of light, a large part of which had been written by Maxwell in 1864. Since then, the second portion of the theory—that dealing with the radiant atom—has assumed larger importance. Any treatment of the production of radiation falls more or less naturally into three parts, namely, (1) the radiation of solid and liquid bodies which is almost, but not quite, independent of atomic structure; (2) the radiation which takes its rise in radioactive substances and which is apparently dependent upon atomic collapse; and (3) the radiation of gaseous substances, dependent almost entirely upon normal atomic structure, and possibly also upon the mode of excitation.

The subject to which your consideration is invited has to deal only with radiation of this third class. Radiation which in terms of the electron theory is said to be due not to abrupt or discontinuous acceleration but to periodic acceleration.

## DEFINITION OF SPECTROSCOPY.

The science of spectrum analysis which was born, one might almost say, in Bunsen's laboratory in 1859, developed within a period of four or five years into a science of a totally different character, a science which enabled Kirchhoff at once to study the physical structure as well as the chemical constitution of the sun, a science which permitted Huggins as early as 1864 to distinguish between star clusters and nebulæ, a science much wider

than spectrum analysis, a branch of learning which we now call spectroscopy. Briefly defined, it is that science which has for its object the general description of radiation, including the production of radiation, the analysis of radiation, the registration of radiation, and the measurement of radiation.

The theory of separating, recording and comparing radiation is by no means simple or complete. That these last three operations demand in practice the highest degree of skill is exemplified by the work of Rayleigh, Rowland, Michelson, Perot and Fabry and Hale.

There is, however, a certain very true sense in which these last three processes are merely preparatory to a more profound study of the first, namely, the production of radiation. From this point of view, spectroscopy hinges upon the radiant atom —if there be an atom—and may be defined imperfectly and narrowly perhaps as *the science of the radiant atom.*

More than one brilliant and partially successful attempt has been made within the last quarter century to establish an adequate foundation for this science by devising what may be called a satisfactory atom. But before considering any of these attempts it may be well to state briefly what seem to be the criteria by which any such foundation is to be judged.

Perhaps it may be fair to consider that atom as most competent which will explain satisfactorily the largest number of the following nine facts.

## CRITERIA.

1. The fact that spectral lines are in general approximately sharp.

2. The fact that spectral lines are never perfectly sharp, but always have a finite physical width.

3. The fact that certain spectral lines are arranged in series and bands after the manner described so perfectly by Balmer's equation and its generalized forms.

4. The fact that increase of pressure causes a shift of spectral lines toward the red as discovered by Humphreys and Mohler.

5. The fact that a magnetic field will transform single lines into multiple polarized lines as discovered by Zeeman.

6. We come now to a group of phenomena which are not easily described under a single caption. I refer to phenomena such as those observed by Plücker and Hittorf, when they found one and the same gas in one and the same tube yielding very different spectra according to the mode in which the electric discharge was applied to make the gas luminous. In the same category doubtless belongs the extinction of air lines by the insertion of self-induction into the discharge circuit. Here may belong also the fact studied by Lenard and others that the region near the electrode of an arc gives a spectrum different from the region near the center of the arc; the fact also that the so-called "spark lines" are introduced into an arc by reducing the current to small values, a fact first studied by Hartmann.

And certainly in this same category belongs the fact that the spectrum of an arc is modified when the arc is surrounded by an atmosphere different from ordinary air.

Here also lie the profound differences between arc and spark spectra of the same element.

Notwithstanding the fact that "multiple spectra" is a term which has hitherto been employed to describe the Plücker tube variations, I propose that we generalize it and use it to describe this entire group of facts. Since the name is so appropriate, let us call the sixth fundamental phenomenon that of "multiple spectra."

7. Any competent atom must allow us to infer the relations which have been proved to exist between spectral phenomena and atomic weights.

8. The phenomena of line reversals and absorption bands.

9. The fact that heat alone, at least within the range of our highest artificial temperatures, produces characteristic spectra in only a few rare instances.

These, briefly, are the parts of the spectroscopic superstructure for which a foundation is sought. These are the various parts which it is hoped will, some day, be cemented together, by a simple and general theory, into a harmonious structure.

But there is a final criterion, even more fundamental than any of those which have been mentioned, that such a theory must satisfy, namely, this hypothetical radiant atom must not

in its behavior, except as a very last resort, contradict any of the established principles of physical science, be they mechanical, electrical or chemical.

The principle of the conservation of energy must be satisfied even if it is necessary to assign an undreamed-of amount of energy to each atom; in like manner Newton's third law is to be satisfied, even if the electromagnetic ether is called upon to furnish the reaction.

But even with this added criterion, the preceding list of nine phenomena is confessedly incomplete; the only object of such a catalogue is to include those typical fundamental facts which ought, apparently, to follow as immediate consequences from the structure of the radiating body, so soon as that structure is correctly guessed. Thus Doppler's principle is omitted on the ground of its being rather a kinematic law, governing periodic disturbances in any medium, than a dynamical fact to be explained in terms of atomic structure and forces.

## THE SATURNIAN ATOM.

Having established a set of criteria by which we may estimate the fitness of a radiant atom, it would be interesting, if I were competent, and if time permitted, to pass in review some of the various atoms which have been proposed in recent times; such as that of Kelvin, 1884, or those suggested by the Hertzian oscillator.

But neither of these two conditions is fulfilled, and I propose, therefore, to consider only one atom, namely, the one which by common consent, I think I may safely say, comes more nearly satisfying the demands of experimental fact than any other ever devised. I refer to the atom first proposed in a general way by Lord Kelvin in his paper entitled "Epinus Atomized,"* and afterwards profoundly modified by Lorentz, Thomson and Larmor.

So much work along this line has been done in the Cavendish Laboratory that one feels impelled to call this "the Cambridge atom;" in view, however, of its structure, perhaps "the Saturnian atom" is a more appropriate designation.

*Baltimore Lectures, p. 541 (Cambridge, 1904).

Now as to the proper conception of the normal Saturnian atom—I am not certain that I know what this is, but my mental picture of it is somewhat like the following:

1. Conceive a single negatively charged electron—whatever that may be—placed inside a mass of positive electrification—whatever that may be. On the basis of the Zeeman effect, we may imagine this electron to be revolving about the center of the positive charge; and we may assume its rate of revolution such that it is in equilibrium under the first-power-of-the-distance law.

But even if we did not have the Zeeman effect to suggest rotation we should be compelled, as Jeans* has shown, to introduce rotation, on the basis of Earnshaw's theorem, to secure stability. Any acceleration of this electron which is periodic will produce a periodic radiation of energy. Precisely such an acceleration is here present in the familiar $rw^2$ centrifugal acceleration which is periodic when we consider radiation along any one fixed direction. The frequency of this acceleration determines that of the radiation just mentioned. The electromagnetic effect is roughly that of an alternating displacement current.

2. Let us next suppose that instead of a single corpuscle we have a large number distributed throughout the same orbit. Their radiation is now almost nil, the vector sum of the accelerations being zero and the electro-magnetic effect being roughly that of a *steady* current.

If the ring does not contain so many of these self-repellent corpuscles as to become unstable we have a simple type of a non-luminous and, during stability, non-radioactive element.

Imagine now that these electrons are the same for all elements, then one element differs from another mainly in the number, disposition and character of the rings which surround the central attracting charge, the number of corpuscles being "of the same order as the atomic weight."†

Such is a rough sketch of the normal Saturnian atom. The beautiful manner in which this structure permitted J. J. Thomson to infer the same periodicity in electro-chemical properties

*Jeans, *Phil. Mag.*, **2**, 425, 1901.

†J. J. Thomson, *Phil. Mag.*, **11**, 774, 1906.

as that contained in Mendelejeff's table is already familiar to you. But for the present inquiry this exquisite achievement of Thomson's is merely an "aside." So also is Drude's elegant connection of electrical and thermal conductivities in metals. Likewise his explanation of the Hall effect.

We come now to the question which is fundamental to all spectroscopic theory, namely, *under what conditions* does a gas atom become radiant?

This question may be asked and answered in two different senses:

First, one may inquire as to the laboratory conditions necessary to produce luminosity in a gas; the corresponding answer is threefold: either a high temperature, thus obtaining, in some rare cases, a heat spectrum, or secondly, a rapid chemical change as in flames, or thirdly, an electric field as in the arc, spark and vacuum discharge.

Again, one may ask what is the difference between the internal conditions of a radiant and non-radiant atom. So far as I am aware, this latter query has never received an answer which is definite or based upon indisputable experimental evidence. However, the Zeeman effect points to rotation in the luminous source and suggests the revolving electron as the light-giving body; but it is difficult to see how one electron could give rise to more than one line in the spectrum. Not only so, but, since the electrons are the same for all elements, it is clear that the electrons alone can not emit characteristic spectra, the "sign-manual of the elements." Riecke and Stark* have furnished us excellent experimental reasons, by observing the motion of luminous lithium vapor towards the cathode, for thinking that the radiant source is the positive ion; this, it will be noted, is not at all inconsistent with the evidence of the Zeeman effect, since the positive ion carries with it probably a large number of negative electrons, being itself merely a neutral atom minus one or more negatively charged corpuscles.

Thomson has recently presented three different lines of argument for thinking that the number of corpuscles in the atom is of the same order as its *usual* atomic weight, *i.e.*, in terms of hy-

* Riecke & Stark, *Physik. Zeitsch.*, **5**, 537, 1904

drogen as unity. But most elements emit a number of spectral lines which is enormously greater than their respective atomic weights.

Thomson is, therefore, driven to conclude that "when an atom of an element is giving out its spectrum either in a flame or in an electric discharge, it is surrounded by a swarm of corpuscles; and combinations not permanent, indeed, but lasting sufficiently long for the emission of a large number of vibrations, might be expected to be formed. These systems would give out characteristic spectrum lines; but these lines would be due not to the vibrations of the corpuscles inside the atom, but of corpuscles vibrating in the field of force outside the atom."* The immediate cause of luminosity would be the bombardment of this system by free corpuscles, or in the case of flames the disturbing cause would presumably be molecular collapse.

At another time and place Thomson fortifies his view as to the complexity of the radiating atom, by citing the discovery of Lenard, that the speed with which the corpuscles are expelled from the atom by ultra-violet light does *not* depend upon the intensity of the incident ultra-violet light; thus indicating the necessity of at least two independent vibrating systems within the radiant atom.

I am not clear as to the proper interpretation of the measurements which have been made by Stark† upon the Doppler effect in hydrogen canal rays; but in any event they would seem to prove that the luminous source in the vacuum tube is not the simple corpuscle of the cathode rays, but the more complex, positive ion (not necessarily the positive charge) of the canal rays. While the experiments of Hull‡ during the past year combined with that of Schuster and Hemsalech point to a luminous source of such size and complexity that a condition of luminosity may be "propagated along" it.

The upshot of the whole matter, then, is that we are landed with a picture of the radiant atom which is complex quite beyond description. One is reminded, indeed, of the words which

*Thomson, *Phil. Mag.* **11**, 774, 1906.

†Stark, *Ann. d. Physik.*, **21**, 401, 1906.

‡Hull, *Proc. Roy. Soc.*, A., 521, p. 80, 1906.

Marie Corelli puts in the mouth of Lionel, the youthful hero of her "Mighty Atom." "Oh, dear Atom!" says he, "you must be very much more than I have been taught to believe you are."

Let us, however, accept the structure as we have received it, and, with apologies for any feature of it which has not been correctly represented to you, let us now ask ourselves how well it can serve as a foundation for our spectroscopic edifice.

## APPLICATION OF CRITERIA.

We may make this test most easily perhaps by asking how this atom will account for the nine fundamental phenomena mentioned above, and—

1. Does this Saturnian system give sharp lines? Can one predict from its structure that its radiation will be concentrated in a few definite positions in the scale of wave lengths? I think it must be admitted frankly that, in the picture of the atom as given us, there is nothing which determines the rate of rotation of the corpuscle in its orbit, and nothing, therefore, which gives the same periodicity of radiation for all atoms of any one element.

This difficulty has been stated in a very forcible manner by Professor Jeans, and again by Lord Rayleigh. Each of them has proposed a method of getting around the difficulty, one* by introducing a law of electrical action different from the simple law of inverse squares, the other† by introducing mobile negative particles, which do not revolve, but which vibrate about their positions of equilibrium located in a rigid positive charge.

But the adoption of either of these suggestions would completely change the entire character of the atom. It may be that we shall later be driven into the corner and be compelled to accept some such mode of escape. But at present these devices impress one as highly artificial, and too inconsistent with other facts to warrant adoption.

The crux of the situation seems to be just here, if one assumes that the frequency of the radiation is identical with the rate of revolution of the corpuscles, he can not expect sharp lines in the

*Jeans, *Phil. Mag.*, **11**, 607, 1906.

†Rayleigh, *Phil. Mag.*, **11**, 118, 1906.

spectrum. If, on the other hand, one assumes that light is due to the internal vibrations of the corpuscles, then not only does be fail to predict the Zeeman effect, but he is forced to conclude that since the corpuscles appear to be the same for all elements, the spectra of all elements should be identical. To derive the Zeeman effect from a rectilinear vibration by substituting for it two circular vibrations would seem to employ a purely kinematic device instead of offering a physical explanation. Nor is this all: The value of $e/m$ obtained from the Zeeman effect is, if not correct, at least in beautiful accord with values determined in a variety of other ways.

Summarizing, one might say that the adoption of the Saturnian atom would compel us either to give up the Zeeman effect, or to give up sharp lines in the spectrum. On the other hand, I am not aware that it has ever been shown that even in a gas-spectrum the region between any two lines *is* entirely free from radiation. Is there any spectrograph so free from diffused light as to make an experimental answer to this question anything other than a more or less rough approximation? But even if every spectrum is, to some slight extent, continuous, the fact remains that spectral lines are essentially sharp.

2. Passing now to the second fundamental fact, which is that spectral lines are *not* perfectly sharp, but (within limits not yet resolved by any grating) possess a complicated structure, Professor Michelson* and Lord Rayleigh† have shown that in the case of a gas at low pressure the chief, if not the only, cause of widened lines is motion in the line of sight, an effect which depends as much upon pressure and temperature as upon atomic structure. But when it comes to the asymmetric distribution of intensity within these narrow lines, *i. e.*, a linear structure such as has been revealed to us especially by the interferometer in the hands of Michelson, an effect which would appear to be a function solely of atomic structure, then the chances of explanation in terms of the Saturnian atom appear even more remote than in the case of perfectly sharp lines.

3. The next query to be presented to the Saturnian atom is

*Astroph. Jour.*, 2, 251, 1895.

† *Phil. Mag.*, April, 1889.

what explanation can be offered for the fact that very many lines in the spectra of the elements are arranged in series such that the wave lengths of any one series are functions of only two constants and the successive whole numbers.

So far as I am aware, no answer which is even approximately satisfactory has ever been offered in reply to this question. The fundamental difficulty here has been shown by Lord Rayleigh to lie in our measure of force, so to speak; in the fact that force is a second derivative of displacement with respect to time. Describe any dynamical system you please in terms of a differential equation; integrate it under conditions which yield a periodic solution; solve for the frequency, and you will find its value always entering to the second power.

But the difficulty under which the Cambridge atom here suffers is not peculiar to it alone.

Ritz,* in a doctor's dissertation of extraordinary merit, offered at Göttingen, has succeeded in devising a formula which contains fewer constants than that of Kayser and Runge, yet represents the observed wave lengths with a distinctly higher accuracy. And it might, at first glance, appear that we have here a truly dynamical explanation of the series phenomenon. But on closer inspection one finds that the fundamental picture —the mechanism, if you please—from which Ritz derives his differential equation is one having properties which are purely hypothetical and, in nature as we know it on a larger scale, quite impossible.

His vibrating body is a square (sometimes a plate, sometimes a membrane) whose behavior he studies under different boundary conditions. But it has this remarkable property: that the effect of any one element of the membrane upon any other element is not merely a function of the distance separating the elements, but varies directly as this distance. A device so artificial could at most be called quasi-kinematical or purely mathematical. However, in each of the particular cases which he has integrated the frequency expression turns out to be practically identical with Rydberg's formula. The only dynamical justification for the entire proceeding appears to lie in the fact

*Ritz, *Ann. der Physik.*, **12**, 264–310, 1906.

that he has chosen a two-dimensional body to yield a double infinite number of spectral lines.

Garbasso* has made an interesting attempt to obtain the Kayser and Runge series from certain combinations of Hertzian oscillators. And his solutions have this special merit, namely, they all refer to physically realizable models. But the number of frequencies which he has computed is too small to furnish even an approximate test as to whether they satisfy the law of Kayser and Runge, much less do they point out a general dynamical system from which the law of the series may be derived.

In spite of the fact that no satisfactory explanation has been obtained, one can hardly avoid the conclusion that Rydberg's formula is something more than a convenient expression for interpolation. The fact that his second constant, $N_0$, is the same for all elements, while another has a characteristic value for each particular element, and that a third constant locates the particular series in any one element, would seem to indicate that these three quantities are in some sense parameters of matter. Yet I am aware that this view is a mere suspicion and is not at present capable of proof.

When other types of spectra, such as that of iron, are brought under the "reign of law" we may find a simpler view; or what is more likely, we may feel, with Professor Runge, that "nature is getting more and more disorderly every day."

4. Passing now to the pressure shift, we owe to Dr. Humphreys, one of the discoverers of the phenomenon, a clear explanation in terms of the Saturnian atom.

He points out first of all that an atom built on the model indicated, with quantitative specifications such as these given, by experiment, will exert an enormously powerful field at points near its center. And since the convection currents here existing are practically equivalent to Amperian currents in circuits devoid of resistance, it is clear that any currents induced in these atoms by attempting to thrust through them more or fewer lines of force than they now contain will be permanent and, therefore, unlike the induced currents in the wire circuits of our laboratories.

* Garbasso, "Theoretische Spectroskopie," pp. 130 and 180, 1906.

But an increase of current in such an atom means an increase of speed in the corpuscles, and this in turn means presumably an increase of frequency. From this it follows that, if by any means two atoms are brought closer together there will in general be a change of frequency and one may expect this change to be sometimes an increase and sometimes a decrease; that is to say, two atoms which are made to approach by pressure, and which we may imagine as strong on a common axis, will sometimes be rotating in the same sense and sometimes in the opposite sense. The increase and decrease of frequency thus secured by pressure will have the effect of widening the line. The plausibility of this argument is much enhanced by the enormous strength of the magnetic field in the neighborhood of one of the magnetic atoms; in the case of the iron atom amounting to as much as 150,000 C.G.S. units at a distance of ten radii from the center and, of course, a thousand times greater than this at the center. So much for the widening due to pressure.

But Dr. Humphreys has also very cleverly suggested that this widening will not be symmetrical about the original position of the line, but about a new position on the red side of the old. For when two atoms happen to be rotating in the *same* direction they will attract each other and then get "into the stronger portion of each other's magnetic field."* In other words, those effects which result in lengthening the waves will be much more marked than those which shorten the waves. Hence increase of pressure will be accompanied by shift towards the red. It would be exceedingly interesting to know what difference of structure exists between the radiant sources of lines and of bands which causes this explanation to break down when applied to the latter.

5. Passing now to the effect of a magnetic field, an experimental fact which largely established, although it did not suggest, Lorentz's conception of the electron vibrating about an attracting center, it is at once evident that the Zeeman phenomenon must follow as a deduction from the Saturnian atom.

But Preston and Runge and Paschen have shown that the normal triplet is by no means an ordinary occurrence; on the

*Humphreys, *Astrop. Jour.*, **23**, 243, 1906.

other hand the breaking up is very much more complicated, a single line yielding anywhere from 3 to 14 components.*

Beautiful as the general agreement between fact and theory here is, one finds it peculiarly difficult to understand how the central line of the normal triplet—the one due to the component of motion along the lines of force—can be split up at all by the magnetic field. But since, as a matter of fact, this component *is* split up, it is only fair warning that the forces here involved are possibly not to be limited to those of purely electrical origin; but it is not obvious what experiment can be devised to answer these questions.

6. Passing next to that somewhat motley group of phenomena which we have classed under the head of Multiple Spectra, I am not certain that there is a single fact in the entire group that can be predicted from the structure of the atom which has been assumed.

In his Royal Institution lecture† of this year, J. J. Thomson has suggested an atom with certain capacities for receiving and spending energy, and has described this atom by simple differential equations, involving certain atomic constants; but the connection between these constants and the Saturnian atom is by no means clear.

So that while he accomplishes the explanation of the phenomena for which this new atom is introduced, the explanation can hardly be said to hinge upon the atomic structure, which has so highly recommended itself in other directions.

At present, we seem to be justified in going little farther than to say that *rapidity of change of electric field* seems to be *a* (not *the*) determining factor in nearly every case. The main difference between the arc and the spark appears to be confined to the earlier stages of the spark. The oscillograph shows that spark lines are introduced into the metallic arc when the break is quickened; the interruption of an intermittent arc is very much hastened by a hydrogen atmosphere; and one might think that, therefore, the action of hydrogen in introducing the spark lines is completely accounted for, and perhaps justly so,

* Runge & Paschen, *Abh. Ber. Akad.*, February 6, 1902.

† Thomson, *Chemical News*, 94, 197, 1906.

if it had not been discovered by Hale, Adams and Gale* that an arc fed by a small steady current and surrounded by hydrogen also yields spark lines. But this calls for an examination of the steady (?) current by means of the oscillograph.

The effect of a very minute current in introducing spark lines probably also rests upon the greater rapidity with which the small current is interrupted. The effect of self-induction is to retard the break, and hence obviously to obliterate spark lines. The effect of a parallel capacity is, of course, to increase the speed of break. The spark lines obtained in arc under water are apparently special cases of the effect of a hydrogen atmosphere and a consequent rapidity of break.

A most valuable research at the present time would be one which would determine whether for a "quickness of break" as a unifying principle we should substitute "rate at which energy is delivered" or, as Thomson suggests, "rate at which energy is delivered *combined with rate at which energy is spent.*"

Until more definite information upon this point is obtained, it remains almost impossible to say how the Saturnian atom must be modified in order to explain multiple spectra.

7. As to the relation between spectral phenomena and atomic masses, we must, I think, all feel the most hearty admiration for the manner in which Professor J. J. Thomson has succeeded in picturing the periodic law as an almost immediate consesequence of the atomic structure which he has proposed. The way in which the normal atom, by the addition of a few subatoms, becomes electro-positive or electro-negative is especially attractive. The achievements of Runge and Precht† in closely approximating, if not accurately determining, the atomic mass of radium is equally striking. Rydberg‡ has pointed out that certain spectroscopic properties of the elements recur with exactly the same periodicity as that discovered by Mendelejeff.

But it is important to observe that in none of these laws is the question of atomic structure involved, but only that of atomic mass. Not a single one of these phenomena has been predicted

*Hale, Adams and Gale, *Astroph. Jour.*, **24**, 213, 1906.

†Runge & Precht, *Physikal Zeitschrift*, **4**, 285–287, 1903.

‡Rydberg, "Rapports Congrès de Physique" (Paris), II., 217.

from previous notions concerning the atom, and indeed all our views concerning the Saturnian atom, with the single exception of the Zeeman phenomena, appear to be singularly devoid of that spirit of prophecy which characterizes all sound theory.

8. When confronted with the fact that many spectral lines show self-reversal, the atom which is now on the witness stand replies that its explanation of this phenomenon is identical with that of any other atom which consists of a vibrating mechanism.

The essential feature of a line reversal appears to consist of a source *within* the arc or spark which emits, from whatsoever cause, a relatively wide line—thus approximating in small degree the incandescent solid first used by Kirchhoff. The *outside* region of the arc or spark emits, from whatsoever cause, a relatively narrow line, and its radiant atoms are, therefore, capable of absorbing only certain periods from those which appear in the broad or inner source.

Accordingly, the phenomenon of reversal is, in a certain very true sense, *not* an atomic problem. The fundamental question here involved is, however, the following, namely: How does it happen that, in the *inner* source, some atoms have their frequencies slightly increased while others have theirs slightly diminished? And this *is* an atomic problem.

We may say that it is due to "increased density" of the luminous vapor, but we are little wiser for that. In this emergency, the Cambridge atom with its entourage of stray corpuscles shows itself very capable; for it is exactly in such a region, as the interior of an arc, where the electric field is strong, and where collisions are frequent, that one might expect this "swarm of corpuscles" to be varying largely—thus altering slightly the period of the radiant source, whatever that may be, both by change of inertia, and by change of electric field—acting, so to speak, both upon the numerator and denominator of the expression for the period. The case of double reversals has been reduced to that of single reversals by the clever experiments of Dr. Humphreys.*

*Humphreys, *Astroph. Jour.*, 18, 204, 1903.

The case of Wolf-Rayet stars* where $H^{\alpha}$ and $H^{\beta}$ are bright while the remaining hydrogen lines are dark is, so far as I am aware, an unsolved puzzle.

9. Regarding the last of the nine criteria which have been cited, namely, the well-nigh impossible feat of securing a line-spectrum from a gas by means of heat alone, the situation seems to be as follows:

If one assumes that ordinary temperatures are due to the translational energy of the atom, while light consists in dissipation of vibrational energy *in* the atom, then Jeans† has proved, on dynamical grounds, that it is possible only in a minute degree to transfer energy "from the principal degrees of freedom to the vibratory degrees of freedom"—at least with any temperatures which are encountered on this planet. In the case of ordinary collisions, the transfer is infinitesimal on account of the high frequency of the vibrations as compared with the duration of the collision; in the case of those rare collisions in which the duration of collision is comparable with the period of vibration, the transfer of energy "is infinitesimal on account of the extreme rarity of these collisions."

This point of view has, I think, been supported by the experience of every one who has attempted to obtain characteristic spectra from gases under conditions in which electrical and chemical processes were excluded.

The assumptions back of Jeans's discussion are to be justified, if at all, by experiment. Hence the importance of such work as that which King,‡ Hale§ and others have recently been doing by means of the electric oven, and of the fundamental experiments of Wood upon optical resonance.

As to the bearing of the Saturnian atom upon this fact, one finds it in about the same position as any other elastic atom, except that for ordinary mechanical rigidity one has to substitute the quasi-rigidity which comes from rotation of the electrons about the positively charged center.

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*Campbell, *ibid.*, **2**, 177, 1895.

†Jeans, "Dynamical Theory of Gases," Ch. IX.

‡King, *Astroph. Jour.*, **21**, 236, 1905.

§Hale, Adams and Gale, *ibid.*, **24**, 213, 1906.

The effort to render a gas radiant by means of high temperature alone has been aptly characterized by J. J. Thomson as an effort to boil a tea-kettle by burning down the kitchen; the spectroscopic analogue of Lamb's roast pig.

In view of all the evidence, the conclusion would appear to be that spectroscopists have greatly exaggerated the rôle of temperature in terrestrial sources. That the behavior of an arc or spark is determined largely by the temperature of its *electrodes* there can be no doubt; but it seems almost equally certain that the effect of changing temperature upon the character of the spectra is produced through the intermediation of changed electrical conditions in the source.

## CONCLUSION.

In turning the pages of Kayser's great compendium, which so adequately represents the present phase of spectroscopy, there is but one tinge of disappointment; and this is that, in the presence of such a wealth of facts, there is so little in the way of fundamental well-established unifying principles. And yet the only remedy appears to be one of the homeopathic sort, namely, more facts.

There is, however, this comfort: things are not as bad as they used to be. Our condition is somewhat that of the old judge who never liked to admit that he was not in perfect health. On one occasion, when he was just recovering from an illness, a friend met him on the street and asked him how he was feeling. "Well!" said the judge in reply, "I am not quite myself, but I am a great deal better than I was at the time when I was not so well as I am now." This, too, is to be remembered, that we can never hope for any solution which can in any sense be called final—*all* solutions are merely passing phases—the problem is not one either of mathematics or of history.

Let us then continue our search for the facts of the case, confident in the belief that when this work has been properly accomplished, the unifying principal will be at hand. It should be to us a matter of no small pride that it is to our fellow members in this section that spectroscopy owes the bolometer, the curved-

grating, the echelon, the spectroheliograph, and, therefore, in large measure the beautiful results obtained with these instruments.

In the meantime we must, I believe, all gladly admit two things: first, that the atom which we associate so closely with the Cavendish Laboratory more nearly supplies the desired principle than anything else which has been offered; and secondly, that the emission of a line spectrum is a very imperfectly comprehended phenomenon.

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THE MOTION OF A VIOLIN STRING UNDER LIGHT BOWING. BY HARVEY N. DAVIS.

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SECTION C.

# CHEMISTRY.

# ADDRESS

BY

CHARLES F. MABERY,

VICE-PRESIDENT AND CHAIRMAN OF SECTION C FOR 1906.

## *EDUCATION OF THE PROFESSIONAL CHEMIST.*

In conforming to the time-honored custom of presenting an address as retiring chairman of Section C, it occurred to me that I might not select a subject more worthy of thoughtful consideration than the education of the professional chemist. In view of the fundamental changes in conditions throughout the commercial world, affecting educational institutions by bringing forward aspects of mental training and practical applications that have no precedents in our earlier experience, it is certainly essential that this influence on modern progress receives critical attention. The recent excellent papers expressing the views of eminent teachers and practical chemists on suitable requirements for the training of young men in chemistry have ably presented the various aspects of this important subject. Yet I have thought that the last word has not been said concerning certain features of professional education, especially relating to the mental attitude of the student, and of the embryo chemist about to enter business life. It cannot be doubted that the courses offered by schools of science deserve all the attention they have received in the form of suggestions and criticisms, particularly from the experience of older graduates gained in close touch with great operations in the industrial world. The term professional chemist is suggested to include

the chemical engineer, the engineering chemist, the expert, and the consulting chemist.

Even those of us who have been actively occupied in the broad field of chemistry as teachers or professional workers during the last quarter or third of the century, find it difficult to realize the great transition within this period. It is inevitable that the all-pervading commercial spirit of our generation should be felt in institutions of learning, perhaps more forcibly in schools of science, where students have an immediate prospect of seeking their fortunes in the absorbing vortex of business activity. The benefits that have come to those institutions as one result of the recent unparalleled industrial and business expansion have been accompanied by certain disturbing influences that are difficult of control. With such a golden flow into the educational coffers, new institutions have grown to large proportions like the traditional mushroom, and the older ones have doubled or quadrupled in capacity and power.

Naturally every student within college walls has his attention attracted to the sources of wealth which provide these great benefactions. It suggests a possibility of a similar pecuniary reward even to the extent of limiting his interest to subjects and their especial features that shall in his estimation lead to immediate advancement and profit on his exit from the collegiate environment. I believe I am stating a part of the common experience of teachers, with reference to the mental attitude of a considerable proportion of the student body. Impatient of attainment along the lines of self-improvement and broad culture, the student regards his institution merely as an influence in gaining an initial foothold, satisfied with the minimum requirements that it will accept for his respectable graduation. I do not wish to express the belief that this feeling is universal, but it is sufficiently evident both as to outward expression on the part of some, and through the influence of association on the part of many, to interfere seriously with the highest ideals of intellectual training. It tends to limit the efforts of teachers to a monotonous routine, and the maintenance of an acceptable standing of students in this routine.

It cannot be doubted that the conditions of instruction in

the higher institutions may be greatly improved by certain changes in the secondary schools. Much has been done within the last few years mainly with the aid and cooperation of teachers in the higher institutions; but the suggestions for better work in chemistry have been limited rather to improvement in methods already in use than to fundamental changes to eliminate primary causes. Judging from the results of entrance examinations, the pupil is taught a text-book rather than chemistry, a fatal error with young pupils, for when they once begin to depend on the printed page, their vision of what they should learn is obscured by their false support. Observation of natural facts should be the only guide until the pupil has a sufficiently well-grounded method to enable him to distinguish between his own observation and printed descriptions. On account of the inherent inertia of young pupils and their inclination to lean on the teacher or the text-book, it is not safe to permit the use of a book until they have acquired a good knowledge of facts and deductions.

Why chemistry should be relegated to the fourth year of the high school, and then suddenly launched on the pupil as a full-fledged science, usually prefaced, as in the ordinary text-book with a series of definitions and a statement of theoretical principles, almost before the correct observation of a single fact, it is difficult to understand. I believe the reason usually suggested is that chemistry cannot be taught to immature pupils of the lower grades. With the text-books at present in use, I appreciate the force of this suggestion, and it applies with the same weight to the grade to which it is introduced, the third or fourth year of the high school. At the age of most susceptible inquiry the child is in an environment in which he is constantly confronted with chemical changes, yet he is permitted to know nothing even of the air he breathes, or the water he drinks, except that the former is hot or cold, and that the latter quenches thirst, until he reaches the age of fifteen or sixteen years. At this period, having spent one-third or more of his time on arithmetic and higher mathematics, and the remainder in text-book drill on other subjects, his mind has lost to a large extent the elasticity of earlier years.

and he naturally attacks any new subject by the same routine methods. It may easily be demonstrated that correct habits of observation and inference in chemistry and certain elementary facts that every person should know can be taught in the grammar grade. The pupil whose school life terminates with the grammar school may demand as his due that he shall receive such instructions. His capacity is fully equal to it; it is necessary with whatever department of business he may be connected; it is one of the most important elements of his education. Why should he not have it? No extensive laboratories are needed; no expensive apparatus. The expense is but a trifle. But it does demand the teacher; one who can put aside the text-book, and present chemical changes from nature's standpoint; one who has the aptitude to lead the youthful mind from the simple observations of every-day life to less obvious chemical changes, until before the pupil is aware of it he has acquired the habit of thought essential to the proper study of elementary chemistry. I grant that the latter requirement is the most difficult of all; but it is one of the pressing needs to place instruction in the grammar grade on a sensible basis; teachers properly trained to teach the elementary facts of nature. With such a foundation the high school course may be made more effective, and it should then properly be assigned to the maturer years. It should include a comprehensive study of facts and elementary reasoning, but with limited theoretical conceptions, which should be left to the broader courses of the higher institutions.

Teachers of large experience who are fortunately in touch with the details of manufacture in large plants, have a vivid sense of the marvelous expansion that is in progress all over the world and especially in our own country. While the practical chemist must know something of all the important branches of manufacture, it is beyond his capacity to acquire a working knowledge of more than a limited range of processes, and to keep pace with the advance in improvements. The outcome of this situation is the intense specialist, one who not only knows what is common knowledge of his subject, but who has carried his study and application beyond the border.

This sort of man is in active and increasing demand; his service is much sought for, and he can command his remuneration. The successful man of business, especially the chemical manufacturer, is of necessity a specialist in his particular field. He is keenly alert in acquiring knowledge of new advances. But in the many ramifications of his business, he oftens finds himself beyond his depth, and it is here that he appreciates the service of the broadly trained man. As never before, successful manufacturing operations are dependent on the application of scientific principles in a scientific manner. Such a position promises most to the young chemist, and the sooner he comprehends its possibilities the more rapid will be his promotion. When he steps out into the great school of active life, so far as his practical knowledge of details is concerned, he should understand in all modesty that he must begin at the lowest round of the ladder. While gaining his business experience and patiently waiting for the opportunities, which will not be long delayed, when his scientific attainments shall be called into service, he will escape the criticism frequently made by manufacturers that the young graduate is apt to assume a grasp of practical details that he has not acquired.

Most manufacturers have a high respect for the advantages afforded by scientific education, and are ready to receive the young graduate with open cordiality, expecting service that they stand in need of. With too great confidence in his grasp of practical details, often the manufacturer assigns duties involving business experience which the young man has yet to gain, with disappointing results. In thus rashly undertaking such work he not only brings discredit on himself, but arouses a feeling of distrust concerning the practical utility of scientific training in general.

It may, perhaps, be said of the professional chemist that his career depends in no small degree on ancestral inheritance. I am inclined to the belief that this is true with reference not only to inborn energy and ability, without which the best success is not possible in any direction, but especially to a certain inherent quick perception and logical turn of mind, that many persons do not possess and can never acquire. Certain it is

that no amount of training can produce a successful chemist out of an individual who lacks these essential qualities. An extended experience in fitting young men for employment in chemistry leads, I think, to the conviction that it is not a large proportion of the average body of students that have the peculiar mental poise and manual dexterity to become successful chemists in a broad sense. As to what should be regarded as success, pecuniary compensation may in general be accepted as a measure of ability, although many men in responsible positions will not accept such a standard since they feel that their service is not recognized in proportion to the profits they help to accumulate in the business treasury. Generally speaking, however, with the unprecedented demand for good men, ability is well compensated. With respect to young men just gaining a foothold there is evidence that their service is appreciated. Statistics have recently been collected from graduates of five years' standing from Case School of Applied Science in all departments, with reference to what salaries would induce them to accept other positions on the basis of what they are now receiving. The average in chemistry was $3,000.00. After ten or fifteen years of service, I have reason to believe that salaries of professional chemists equivalent to $5,000.00 and $10,000.00 a year are not uncommon. While the standard of pecuniary compensation is not unreasonable from the point of view of the man of business, who looks on his ledger balance at the end of the year as a measure of success, the professional chemist seeks also a higher reward. He cannot sever his mental connection from the profound truths of nature, and the more he struggles for the mastery and utilization of those truths, the deeper becomes his reverence for the immutable laws that control and direct his efforts. He is constantly under the stimulating influence of new discovery and an expanding field of usefulness. It is, perhaps, unnecessary to suggest that this does not apply to the man who is content with a daily routine, with no connections outside of his laboratory walls, but, as mentioned above, to one who is equal to present demands; who is alive to the advance of knowledge in his particular field the world over; who is able to keep in touch with new applica-

tions and new processes, and to apply them with discretion. To such a man, imbued with the spirit of research and the instinct of successful application, the best reward for unselfish effort is its appreciation from the point of view of professional standing, which even the manufacturer, after he is assured that the ledger balance is satisfactory, is eagerly ready to recognize.

An incidental advantage to the professional chemist, one of the features of his education, is the readiness with which he is able to grasp the essential principles of business operations. I have been impressed by the frequent expressions from older graduates as to their feeling of indebtedness to a chemical education for success in the application of business methods. They recognize the fact that the close observance in experimental study, constant exercise in inductive reasoning, and the consequent truthful attitude of mind, the directive forces in the study of chemistry, establish in the individual the habit of looking at all matters that concern him from a similar point of view.

If this be the situation that confronts the young graduate when he enters business life, what shall be his preparation for the duties that await him? What is the responsibility of the institution that sends him forth? First of all, he must be a well-balanced man physically and mentally, alert to the individual duties of life. The best success in any department of activity depends primarily on the service of a well-nourished, healthy body, and such health and strength is dependent on the observance of correct habits of bodily attention and nutrition, established in early youth. During the critical period of school, and collegiate training, it is imperative that the excessive mental strain be supported by systematic physical exercise, or the individual will suffer. It is incumbent on an educational institution to provide suitable physical exercise and to require it of every student. Man is a creature of habit, and correct habits early formed are more readily observed in later life.

In the technical preparation for professional employment, as suggested above, the education in chemistry should begin

in early years in the grammar grade; correct habits of observation and reasoning should be made a part of the youthful mental equipment. In the higher institution, without interfering with the time devoted to strictly professional studies, sufficient time should be allotted to language and literature, history, philosophy, and economics, to impart breadth of thought and to supplement the culture of the science courses. I am not in sympathy with the thought sometimes expressed that science and science studies do not contain the elements of culture. On the contrary, I believe that the best culture is derived from the proper study of physical science. Why should it not be? Is it reasonable to assume that all culture is limited to the study of man with his imperfections, and his works, what he has been, what he has done, excluding the perfect laws of his environment, the universe? It is evidently true that science courses alone do not lead the student to broad conceptions of his duty to society and his relations to the community, unless they are supplemented by courses, as suggested, in other departments of learning.

In the training of the professional chemist, two facts should be kept in view. Primarily, he must understand chemical changes. Secondly, he must have the ability to devise and operate machinery and appliances in which chemical changes are to be applied on a manufacturing scale. It would seem that the tendency in some of the modern courses in chemical engineering is to give too great prominence to the engineering features at the expense of time that should be devoted to chemistry, with the production of neither an engineer nor a chemist. There is not time in a course of four years to make a good chemist and a finished engineer in the same individual; neither is it possible to make a good chemist without sufficient time and attention for comprehensive training in chemistry. But it is possible to make a good chemist and to allow him adequate time to gain such knowledge of the engineering features as will give him a good foundation for expansion when he enters the factory. In all departments of business the individual who has learned how to do things himself is best fitted to direct the efforts of others; the superintendent who can saw off a board

by the square or set a post straight and true, can instantly see whether another is doing his duty. The broadly trained chemist must, therefore, have had practice in handling tools, in working wood and iron; he needs the elements of construction, of machine design. He must understand the economic production and application of power from different sources. An important part of his equipment is the nature and manipulation of electrical currents and machinery. Such breadth of knowledge may be gained in courses on shop practice, thermodynamics, applied mechanics, heat and steam, hydraulics and machine construction, attendance on courses in electricity with laboratory practice.

In this connection the recurring question of adequate time in the ordinary course may be satisfactorily answered by the tendency in most institutions to extend the limits of practical work. In Case School of Applied Science, the entire month of June is given up to laboratory and field work as a practice term, which adds about one year of practical study to the course of four years. The student is under constant supervision, with sufficient oral instruction to keep him intelligently occupied. Continuous laboratory practice accomplishes very much more than the interrupted hours of the other terms. In answer to the possible objection that it is some infringement on the time for lectures and recitations, it is true that two or three weeks a year are lost to these exercises; but what is gained in practical application in chemistry makes it about equivalent to a course of five years, and the average student is easily able to accomplish the work mentioned above in mechanics and electricity. Indeed before this recent change in the additional time devoted to the laboratory, our best students and even those of average ability by dint of hard work were able to finish this course. With no sacrifice, therefore, of necessary training in chemistry, the student receives what is needful when he enters on the practice of his profession. Such a course may be designated as engineering chemistry, in which the student becomes primarily a chemist.

To acquire an adequate grasp of foundation principles in chemistry it is necessary to include thorough comprehensive

courses in general inorganic, analytical, theoretical and physical, and organic chemistry, with much time devoted to laboratory work. This routine is practically the same in all institutions with increasing attention to experimental physical chemistry. It seems scarcely necessary to allude to the subsiduary subjects: English, modern languages, mathematics, including calculus, descriptive geometry and drawing, physics, mineralogy, elementary use of surveying instruments, and metallurgy, without which a course in engineering chemistry could not be regarded as complete. The increasing importance of bacteriology in the fermentation industries and sanitary chemistry render it indispensible that the student has some practice in the manipulation of bacteria, and general use of the microscope. He must understand the composition, methods of analysis, valuation and uses of solid liquid and gaseous fuels, and the methods of heating and lighting. In the work of the fourth year, it is essential that the student be led to some extent at least out of the routine of the previous years, to develop greater self-reliance, and to be brought into somewhat close touch with chemical literature, to establish the habit of ascertaining what has been done in any special line of work before undertaking it himself. It is important that he gains a clear understanding of the proper methods of attacking new problems and that he appreciates the necessity of depending on his own resources. In the ordinary course of four years the time that can be devoted to such study is much too limited, but it should be insisted on to the fullest possible extent. The atmosphere of the laboratory should have the stimulating influence of original research. If students feel that they have something before them beside the routine courses it keeps them up to their best effort; they quickly perceive the difference between the spirit of an instructor who has no ambition beyond the hourly recitation and that of one imbued with enthusiasm of original study, and eager to impart something of his own impulse.

Since the chief aim is the preparation of the chemist for efficient service in the manufactory, an essential feature of our discussion relates to the method of teaching industrial chemistry. Evidently in a well-balanced course this instruction should

be preceded by the routine work of the first three years, general, analytical, physical, and organic chemistry, all of which is a necessary preparation. Since there is at present nearly as great a demand for men in positions where organic chemistry is requisite as in places which concern inorganic processes alone, the student must be well grounded in theoretical and practical organic chemistry, when undertaking industrial chemistry. I have found it an excellent plan to carry along the course of organic industrial chemistry in the same term with lectures and laboratory practice in organic chemistry. Every operation in applied chemistry is so closely attended by physical conditions affecting economic results, it is necessary that attendant conditions of processes be kept constantly before the student. As one of numerous examples that may be suggested, vapor tension, heat of solution, vaporization, specific heat, are closely connected with distillation, solution, crystallization and purification.

The schools of science owe their foundation primarily to the labors of self-educated men, who without the advantages of systematic training have devised and perfected on a business basis the fundamental methods of the factory. In taking up the burden of his forebears the young graduate is expected to extend it with the advance of modern demands. Shall the school of science attempt to duplicate in a miniature fashion the factory methods with suitable machinery and appliances, or shall its efforts be directed toward broad training in fundamental principles with such laboratory applications as are needed to comprehend an expansion to a manufacturing scale? Evidently this question should be considered from several points of view. It must be remembered that application on a laboratory scale of any manufacturing process in a manner to afford satisfactory results needs more time than can be found for it in the course of four years, unless it be taken as a subject of a thesis when sufficient time may be devoted to a single subject. But general application should include a considerable number of processes. Depending on the nature of the process, not less than two weeks to two months must be exclusively devoted to any important single operation, and the

benefit derived is limited mainly to this process. Another serious hindrance is the magnitude of an adequate equipment. A separate plant of two or more buildings is needed, for the dust and dirt of one variety of process could not be tolerated in the cleanly conditions necessary in others. With sufficient equipment a graduate course should afford ample time for such work on a broad plan. Such a course should evidently include a study of details and conditions with reference to possible improvements. It cannot be doubted that an adequate equipment in teaching force and plants working in conjunction with manufacturing establishments, and with sufficient endowment for the costly operation should form the basis for the expansion of a profitable graduate course. A school of science fortunately situated in the midst of a great variety of manufacturing operations has the immense advantage that the manufacturing plants really constitute an important adjunct to its equipment. After thoroughly reviewing the details of a manufacturing process in lectures and recitations, next to actually conducting the operation, the student receives a part of his most valuable experience in inspecting such operation under intelligent guidance during his visits. It is a mutual advantage to the institution and to the manufacturer, for it is an invaluable aid to the courses of instruction in the former, and it insures to the latter a more practical knowledge of processes to the student whom he may later employ.

With the most elaborate experimental preparation, however, the graduate approaches a different atmosphere when he enters the factory where every effort has a pecuniary value. Outside the factory it is not possible to take into account the element of costs, which is the controlling principle in any business. It is easy to ascertain the market values of crude materials and finished products, but the long array of numerical details intervening which constitute the business of manufacture is a closed volume to every one outside the counting room. The guiding thought of the student is the acquisition of accurate knowledge of principles and methods. The chief aim of the manufacturer is to apply those methods in such a manner that the pecuniary results may be entered on the right side of

the balance sheet in the shortest possible time. As an example of this difference in motive it is often suggested that students in quantitative analysis be given practice in rapid application of methods; but the fact is forgotten that the student is fully occupied in the attainment of accuracy, and that rapidity is soon acquired. It may take him a day or two to master the necessary dexterity in applying the method for the determination of phosphorus in a single sample of steel. When he goes out into the factory laboratory he may be required to hand in results on thirty samples in a single day. This distinction seems to be best expressed by the difference in environment; the student acquires his knowledge in the quiet atmosphere of the educational institution; the man of business applies his knowledge under the stress of manufacturing conditions.

The service of the school of science for the benefit of the community is well established, but it has not yet secured the tenacious hold of the older college, which, in educating generation after generation, father and son, has established the traditions of the family on scholarship and culture, and extended the influence of collegiate training into the professional and business world. The first generation of graduates from the scientific school has had barely time to make its record, but an honorable record is assured, and it will be continued by their sons and grandsons. Traditional family support of an institution is one of its most valuable assets intellectually and pecuniarily; fortunate is the institution that has this support in the best families.

The school of science in its breadth of training and scope of applications is peculiarly an American institution. In England, until recently, the spirit of progress along similar lines has been somewhat inactive. But aroused by the recent great industrial activity to the fact that their old time plants must be rehabilitated and that our young men are being called on for assistance, large grants have been made to establish schools of science, and the managers of these funds are inquiring with much interest into the foundation and operation of our scientific institutions. The fact is being recognized that the busi-

ness world is receiving aid from practical methods that they must adopt to regain their industrial standing.

In Germany the conditions are essentially different. While the labors of the early French and English investigators contributed very largely to the foundation of chemical science, our immediate inspiration came from the German laboratory. More recently the unprecedented expansion of our national resources has developed circumstances so fundamentally different, our institutions have of necessity directed their efforts toward meeting business requirements to the extent that they are unique. Yet the atmosphere of quiet scholarly inquiry of the German institutions still retains its influence. The great body of German scholars in happiness and contentment devote their lives to discovery and elaboration with sufficient remuneration for economical living and simple habits, and the world is benefited by their labors. In the great manufactory such as that of the Badische Aniline Fabrique or of Meister, Lucius and Bruening hundreds of chemists are employed, a large proportion with Doctorate degrees from the universities. Those men are devoting their best efforts to the interests of their employers in the national spirit of faithful application and with very moderate compensation. If such establishments were compelled to pay salaries equivalent to those granted for similar service in our own factories, it would doubtless make a serious inroad in the very generous dividends they are now able to declare.

It is extremely doubtful whether the conditions in the German university, including their long vacations, their leisurely habits during the semesters, and with no restraint on the student except attendance at final examinations, are applicable in American schools of science. Certainly their traditional method of allowing the student, whatever his capacity, to work out problems on his own resources, even before he is well grounded in breadth of practical methods, could not meet our requirements.

I am sure there will be no dissent from the view that original research is of equal importance in the school of science as in the university, although evidently it should take a somewhat differ-

ent form in the scientific institution. In the university laboratory, research has for its object the advancement of knowledge with no visible practical utilization. The same spirit must pervade all research; that is, its foundation rests on the principles of pure science. In the scientific school the great field includes the application of the principles of pure science to the solution of commercial problems. To one who is conversant with the conditions in the manufacturing plant that lacks the aid of men skilled in science it is evident that much of the work is the result of disconnected observations loosely made in a rule-of-thumb fashion, rather than the outcome of systematic study of underlying principles with expansion to methodical application. There is urgent need of the extension in all directions of the critical comparison of methods of analysis and testing which has made such a good beginning. To appreciate the importance of this work it is only necessary to glance at the want of concordance in the results of analysis of a given substance even from the best laboratories. The recent establishment of the National Bureau of Standards is an excellent foundation for greater accuracy and closer agreement in the results of different workers.

The education of the professional chemist is concerned in the recent discussion on the relations of the scientific school to the university, and the cogent reasons suggested for its rehabilitment as one of the professional departments with law, medicine, etc. If such a change were feasible doubtless scientific education should proceed along much the same lines, for the seeker after its benefits could not otherwise secure his training, and the instruction would of necessity conform to the demands of business. The endowment of other schools of science is not probable; the present tendency is rather to expand scientific training in institutions already established. This is especially true of the state universities in some of which the best practical training in science is given. The permanency of those institutions in their reliance on the state gives promise of the broad development of practical science. What may be said in this direction relates, therefore, to a comparatively few institutions, and it evidently applies to a few conditions concerning

which there are doubtless differences of opinion—culture, educational atmosphere, policy of management, economy in resources. That the student of applied science should gain in culture and breadth of thought in the university atmosphere may be true with corresponding changes in his work; but the strictly professional training cannot be abbreviated, and it is believed that culture should be imparted in these courses as now conducted in the scientific institution. As to whether the university atmosphere is well adapted to the close application and vigorous effort required in the school of science, may be questioned. Beside certain small economy in office supervision it does not appear that any important reduction in running expense is possible. There is a limit to the number of students in a single recitation or laboratory division. A given number of students in the scientific school needs the same number of teachers and the same equipment as in the university.

In respect to policy and administration it would seem that the school of science has an essential advantage over the professional department in the university. The head of the scientific school devotes his best thought and energy with an intense personal interest to his institution. Such devoted service from a president thoroughly imbued with the scientific spirit, with such expert knowledge and force of character that his word has carrying power with the public and with governing boards as well as within the institution, and with business instincts that enable him to meet men of affairs on grounds of mutual interest and understanding, must of necessity be more efficient than that of the dean who is interested in his department as one element of a great university, not wholly independent in applying his convictions nor untrammelled by other considerations incident to his department. It is no doubt true that the conditions affecting the school of science in its relations to the business world are essentially different from those of law and medicine, as integral elements of the university.

With reference to a combination in resources which is the chief source of strength in the great modern business corporation and its application along similar lines in the university, the successful element in the manufacturing corporation is the

elimination of manual labor with its uncertainties and imperfections, and its more general displacement by machinery that is invariable in its operation. It is admitted that without the larger substitution of labor by machinery, the same efficiency and economy are not secured in manufacturing plants in which details are altogether in the hands of salaried employees, as was possible in the earlier period when smaller branches of business were under the direct personal supervision of the owners. On the other hand, in the educational field, mind is the immediate controlling and directing power in every detail with no intervention of mechanical appliances. The teacher cannot direct his students and carry on his instruction from a distant city, or from another continent.

The essential principle of combination in business that modern conditions demand great accumulations of capital and resources for control in competition and commercial fluctuations does not apply in a similar degree to any successful educational institution, for there is a far greater demand for graduates than can be supplied, and there is little difficulty in securing necessary funds for carrying on fundamental lines of educational work. If it be true as has been stated that the German universities are much overcrowded with respect to employment ofter graduation, and that strenuous efforts are put forth through German residents in this country to place their graduates here, the element of competition is not wanting, or may not be in the immediate future. Such competition may even be a stimulating advantage, inciting the workers here to greater effort. Already we have cause for congratulation in the standing of our research laboratories, especially in physical chemistry. It is an indication of a leading position in research and the advancement of knowledge to which the devoted labors of the numerous able investigators in this country during the last thirty years have contributed. A powerful aid which it is all too soon to appreciate in its desirable results, is the immense funds for research recently established. Although primarily these grants are made in furtherance of work in pure science, evidently applied science and professional chemists will be greatly benefited. Perhaps the wisest grant of all is the Car-

negie foundation for the retirement of teachers, for in a measure it relieves the teacher during his earlier years from the anxiety of later need, and gives him courage to devote his residual energy in some efforts for the advancement of knowledge. Every institution named in this grant is benefited in its standing, for it may insist that applicants for positions have adequate training for research, and that their ambition lies in that direction.

In the changes in business management during the last decade, and the transfer of business control from private ownership to great corporate bodies in which the vested property rights have passed into possession of the general public by the distribution of shares and bonds, there is an indication of a tendency toward the creation of a class distinction in labor as well as in property control. It is not at present so apparent in its results as it will doubtless appear later when the very prosperous conditions of business and consequent increase in private fortunes and lavish expenditure shall inevitably be affected by enforced economy of a more stringent commercial situation. At present all forms of labor are employed with increased compensation and with a serious deficiency in many directions. But there is an evident tendency toward a lower valuation of mere manual force and an increased valuation of mental agency. In corporate control success depends, in some directions altogether, on the personal qualifications of a superintendent or manager, and the right sort of men are much sought for and difficult to secure. The pressing need is for managers of executive capability for manipulating men and methods, and it has developed so suddenly, it is all too soon for the production of an adequate supply. A great business corporation can be created in a day; but years are necessary to produce men who can manage its departments.

Class distinction in labor will appear in the elevation of skilled labor, the thoroughly trained man of science of executive ability, and the manager, and the degradation of brute force as it is embodied in the individual whose possession consists only in what nature has conferred on him. What will become of the latter as the labor of his hands is more and more

completely replaced by machinery that can do his work better, is one of the great problems of the future. It will be a question of the survival of the fittest, and one that has a lively interest for the youth who is now deciding what his future shall be, for this, and other similar phases of social and industrial life will be brought prominently into view during his generation.

A feature of modern progress that has an intense personal interest to every individual in active business life is the tenure of activity. Formerly the connection with affairs of business was co-incident with life itself. But the old-time methodical, slow-moving habits of the last generation of business men whose attendance in the counting room included the daily working hours, has given place to close connections by telegraph, telephone, limited trains and other inventions that tax human endurance. The father attended to his correspondence, writing all his letters; the son takes up a pen only to sign checks and documents. The youth of the present day must amass his fortune, make his reputation, get his enjoyment and pleasure in business affairs and be ready to resign his place to another at the age of fifty or sixty years, at just the period of life when the normal man should be in his prime, and able to render his best service by reason of his experience and mature judgment. This is a serious limitation for young men who have spent eight years or more of their lives in gaining an education, although the graduate of the school of science has an advantage over those who select other professions that require three years or more of additional preparation, which with subsequent office practice render it scarcely possible for the young lawyer or doctor to start out in business for himself much before the age of thirty years. In taking a position immediately after graduation in the manufactory the man of science is making his way while he is gaining his business experience. Ten or fifteen years at least are necessary to develop the productive capacity of any man, and the remaining few years permitted to him for accumulation demand the utmost concentration of effort. What will be the result of this intense strain, and the effects of such a time limit on what the average man hopes to accomplish, can only be ascertained by future

observation. But the situation is inevitable, and the young man is wise who heeds for his future the counsel and experience of his elders.

It would seem that these various influences have an important bearing on the present and future conditions of practical education in determining what the student may expect who seeks a suitable preparation for the profession that will absorb his best energies and that shall constitute his life work. It is of less consequence where he is educated provided he attains the mental poise and attitude that enable him to grasp fundamental truths and to apply them correctly in the accomplishment of great undertakings.

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DETERMINATION OF ACETANILIDE IN HEADACHE POWDERS. BY ATHERTON SEIDELL.

SECTION D.

# Mechanical Science and Engineering.

ADDRESS

BY

F. W. McNAIR,

VICE-PRESIDENT AND CHAIRMAN OF SECTION D FOR 1906.

## *SOME PROBLEMS CONNECTED WITH DEEP MINING IN THE LAKE SUPERIOR COPPER DISTRICT.*

The copper mines of the Lake Superior district are essentially low grade. Their profitable operation is made possible by the great extent of the lodes, their comparative uniformity of character, and the investment of great sums of money to maintain operations on a vast scale over a long period of years.

With but one important exception, the lodes are the vesicular tops of ancient lava flows which, subsequent to solidification, have had the cavities wholly or partly filled by the deposition of various minerals, among which is native copper. They dip at angles varying from 38° to 70°.

The modern shafts through which the rock is hoisted are either inclined, following the plane of the lode, or are vertical. The inclined shafts are of dimensions such as to provide for two railroads of approximately standard gauge on which run the "skips" which are operated in balance. In addition there is room for the ladder way and air pipes, usually placed at one side. The vertical shafts have compartments providing usually for "cages" and pipe and ladder way. Several of the inclined shafts are over 5,000 feet long. One has a length of 8,100 feet. Of the vertical shafts the three deepest are, respectively, about 5,200, 5,000, and 4,900 feet deep.

Long before such depths were actually reached there arose the question as to a possible limit set by the ultimate crushing

strength of the rock which is penetrated. Manifestly, mining cannot go to a depth such that the weight on walls of drifts and stopes will exceed the ultimate strength of the material of which they are composed. There is a widespread impression that the lake mines are approaching such a limit. There are current statements to the effect that pieces of rock occasionally snap off the rock faces because of the great strain, and are violently projected as if propelled by an explosive.

In this connection a few figures will be of interest. The average density of the rock of the copper-bearing series is not far from 2.87, that is, a cubic foot weighs about 179.3 pounds. Therefore, a horizontal square foot of area at 5,000 feet from the surface has above it a column of rock weighing 448 tons. The ultimate crushing strength of the average rock is not well known, but since it is mostly trap this may be safely assumed as at least 1,200 tons per square foot. If, therefore, the square foot above defined carries the entire column above it, it is loaded to much less than half the crushing strength and only at nearly three times the assumed depth will the load reach its crushing limit. At a dip of 38°, the pressure normal to the plane of the lode at 5,000 feet from surface is only 354 tons per square foot. It is in this direction that the crushing forces are mostly called into play. As the dip increases this normal pressure of course diminishes. At 52° it is 278 tons, and at 70° it is 152 tons per square foot.

However, the matter does not end here. The removal of large portions of the copper zone leaves considerable areas of the roof or hanging wall to be supported by the pillars which are left for the purpose, or by the walls of the opening, or by both. The weight on pillars and walls is thus increased and may easily approach the crushing limit. Take, for example, a long pillar 50 feet wide having on either side an open space of 150 feet. Suppose it in a lode dipping 38°. Allowing for neither rigidity nor arching, and supposing the weight on the pillar evenly distributed, at 5,000 feet deep it would be subjected to a pressure of 1,239 tons per square foot, a pressure under which it would fail.

As a matter of fact, in such a case the rigidity of the rock

mass distributes a large part of the load out over the rock beyond the walls of the opening. That this rigidity may be considerable is illustrated in several cases where areas of hanging as wide as 200 feet or more have no support between walls, and yet have stood up for several years. They are not, however, at maximum depth.

In such an area a pillar when first cut out may have to carry but little more than its previous load. As the hanging wall slowly bends the pillar must take up more and more of the extra weight. This is not applied uniformly. As the rock between pillars and walls bends downward the tendency is to concentrate the load at the edge or face of the pillar, or wall, much as a beam does when supported in like manner. The outer parts of the pillar may thus become overloaded and here it will fail.

It does so by the splitting off of pieces of rock much as may sometimes be observed with a specimen in the testing machine, though on a much greater scale. These pieces break from the base as well as the top, and, as a rule, like any hard rock under a crushing load, the pillar fails suddenly. Small pieces of rock may fly to a considerable distance, and such occurrences have undoubtedly given rise to the above mentioned exaggerated impression of the compressive stress to which the rock is subjected in the lowest levels.

The hanging rock mass moves, of course, when the pillar crushes, and the vibration due to the sudden though slight displacement is often conveyed to the surface. The result is a miniature but perfectly genuine earthquake which may be felt over a distance several times that of the pillar from the surface. With the crushing of the pillar and the movement of the hanging a readjustment of the weight takes place, and the process begins over again. Instead of the process being repeated exactly it is possible for the hanging to break in such a manner that the arching effect may protect this pillar, and place the load on others. Eventually, at great depths, the hanging and foot must come together, and in one mine the final steps in the process came so rapidly as to completely wreck it.

The pressure normal to the plane of the lode is not the only action which may appear. The pillars are not, as a rule, sepa-

rate from either foot or hanging. They are parts of the same rock mass, and it is not possible for the hanging to slide over the pillar. In consequence the readjustments which take place when a pillar fails as above described sometimes put an enormous longitudinal thrust on the foot, and in places its surface portion has buckled up under such stress. Also, at points where shaft pillars have been weak, shafts have been pinched and twisted under the same conditions so as to interfere with their operation.

Experience seems to have shown that at the great depths recently reached it is useless to expect to hold up the hanging rock mass for a long time by any scheme of pillars unless far too much of the lode is left in place, and that the only feasible method is to cut away the entire lode and permit the hanging to cave as rapidly as it will to the point where the broken rock fills again the whole space, and redistributes the weight over the footwall. Following this plan, cutting out the lode, or "stoping," begins at the point furthest from the shaft, and progresses toward it. With a wide shaft pillar, or with the shaft in the footwall, with some such general method which avoids concentration of pressure where it can do harm, there seems no reason to anticipate serious difficulties due to crushing for a further depth at least as great as that already attained.

The difficulties of surveying the mine are not markedly increased by depth, except in the case of vertical shafts. When these are deep, and it becomes necessary to carry down an azimuth from the surface by means of two plumb lines hung in the shaft, there is presented a problem of considerable difficulty. It is almost impossible to free the lines entirely from disturbing influences which displace them from their normal positions. If either lines or plumb-bobs are of magnetic material the presence of iron pipes in the shaft may result in seriously disturbing them. Falling water may be in such quantity and so directed as also to affect the position of the lines.

However, the air currents, which can not be wholly eliminated whatever the precautions taken, are the most serious cause of disturbance. The temperature at the bottom of the shaft is higher than that at the top, and in consequence convection currents are formed. The heat supplied from the surrounding

rock keeps them up. Indeed, with moderately steady temperature at the surface, and with the shaft idle, a remarkably stable condition of these air currents may come about. Elsewhere observations have been published by the writer,* showing that their effect on a plumb line may remain sensibly constant for hours at a time while deflecting the line from its vertical position. The stability of the currents is made possibly by the large gross section of the vertical shafts, 10 feet by 22 feet to 10 feet by 30 feet outside of timbers, thus giving a large air body, and the constancy of the rock temperatures, and the supply of heat through the shaft walls. When we take account of the fact that a force equivalent to a horizontal pressure of 10 grains on a 60-pound plumb-bob suspended by a line 4,000 feet long will displace the bob one-tenth of a foot from its normal position, it is easy to see how apparently slight causes may produce appreciable error in azimuth.

General attention was first attracted to this problem by the very noticeable divergence of two long plumb lines hung in shaft number five of the Tamarack mine. Of course, divergence alone would not affect azimuth, but the question confronting the surveyor is whether the divergence may not be due to some cause which may also displace one or both of the lines in a direction perpendicular to their plane. In the case mentioned it required a great deal of investigation and experiment to fasten the responsibility on the currents of air.

It is remarkable how many persons are ready to accept as an explanation of such divergence the statement that there is an excess of gravitation on each bob horizontally toward the end wall nearest to which it hangs. All are familiar with the picture in the text-books of the plumb line hanging near the face of a precipice being deflected from the vertical by the attraction of the mountain mass. The idea so strikingly conveyed by this picture, while qualitatively correct, seems in most minds to be quantitatively wrong. There is an excess of attraction on the bobs as stated, but its amount is far too insignificant to account for any observed divergence. At Tamarack number

*See *Engineering and Mining Journal*, April 26, 1902; Also *Electrical World*, April 26, 1902.

five it could account for no more than one one-thousandth of a foot. The convergence of vertical lines in that instance is over three times this amount.

The fact remains that the surveyor who must thus transfer an azimuth from the surface down a very deep shaft has a problem, the proper handling of which must involve a careful study of the local conditions, particularly in regard to air circulation.

Increased depth tends to lessen the output of a given shaft, and in the effort to prevent this, and also to reduce hoisting charges, loads have grown larger, likewise the speed at which they are hoisted. Loads of nearly seven tons are being raised on some of the inclines at speeds up to 40 miles per hour.

A considerable item in the hoisting charges is the cost of maintenance of the skip road, the expense per ton for this purpose increasing with the length of the shaft. The usual skip road is carried on heavy timbers which are placed transversely along the foot, and support large stringers to which the rails are spiked. The expense of maintenance of this road for great depths is such that some of the mines are substituting for it a road consisting of a rail attached to a concrete stringer which is borne directly on the rock of the footwall.

The stringer proper is about 13½ inches wide by 14 inches high. Beneath it and supporting it is a mass of concrete 16 inches to 18 inches wide extending to the rock. The depth of this supporting mass varies considerably, depending on the irregularities of the rock face to which it is attached. It ranges all the way from 4 inches to 2½ feet, and there is no reason why these limits might not occasionally be exceeded. The stringer and supporting mass are structurally one piece, being molded together. The stringer portion is reinforced by means of a 1⅛-inch steel cable passing longitudinally through its interior. The rail is attached by bolts which are spaced three feet apart, and hold it by means of clips which grasp the rail flange. The bolts pass through the stringer into a rectangular opening about three by four inches in section, which passes quite through the concrete, and affords access to the lower end of the bolt.

In building the road a form of plank is constructed having

the cross-section of the stringer, and a length of 15 feet. To its lower side are nailed the cores for the bolt openings just mentioned. The top is left open. From one to three of these forms are supported in place underground by suitable means, and to the sides are nailed boards extending downward to the rock. These make the form for the supporting part underneath the stringer proper. When all is firmly secured the rock face is thoroughly washed, and the concrete is filled in, beginning at the lower end. The mixture used is one part Portland cement, three of sand and five of crushed rock, and it is tightly rammed in place. As the filling proceeds, the top of the form, or the cover, is completed by nailing on short pieces of plank. In the roads which have been built at a slope of 70° the structure is anchored to the footwall by heavy bolts spaced 8 feet apart. When the concrete has hardened sufficiently the form is removed and the rail is bolted in place. The road is then complete.

The first of these roads has been operating some three years, and has proved so satisfactory that the others have followed. Expectation regarding cost of maintenance has been fully realized, and, in addition, it has been found that the original cost of the road is less than that of wooden construction. Its disadvantages seem to be confined to the fact that, due to the unyielding nature of the support, the effect of a blow must be absorbed between wheels and rail, resulting in a perceptibly greater deterioration of both. However, this is far more than compensated by the decreased cost in other directions and the fireproof character of the road.

In the effort to counteract the increased costs due to great depth the economical generation, distribution and use of power have naturally received large attention. The long period of operation necessary makes it worth while to expend large amounts of money in installing machinery of large capacity and high economy. The extreme in the direction of high-duty engines is represented at present in the Nordberg quadruple expansion, two-stage air compressor operating at the Champion mine. The engine is equipped with Nordberg's regenerative feed-water heating system. It holds the world's record for minimum consumption of heat per foot-pound of work delivered,

having shown a duty of 195,000,000 foot-pounds, being about 9 per cent. in advance of its nearest competitor.*

But one mine is so situated to be able to make use of water power. The Victoria, located near the Ontonagon River, has a considerable water power available which has been utilized in a novel manner. Distance from source to points of application is not great and the power for both mine and mill is distributed by compressed air. Moreover, the falling water operates directly on the air without the intervention of water-wheel or other machine.

Roughly speaking, this "hydraulic air compressor" consists of a large underground chamber cut from the solid rock and having a length of 281.5 feet, a width of 18 feet and a depth of 26 feet. In normal operation the lower portion of the chamber is filled with water to a level of 14.5 feet from its roof. The remainder, having a capacity of over 80,000 cubic feet, is filled with air at 114 pounds gauge. The water outlet is through a tunnel 18 feet wide and 10 feet high, the bottom of the tunnel being a continuation of the horizontal floor of the chamber. This tunnel opens into an inclined shaft about 18 by 20 feet in cross-section, the discharge level of which is 271 feet above the water level in the chamber. The outlet for air is a 24-inch pipe leaving the chamber through the roof directly above the tunnel outlet.

The inlet for both water and air is through three vertical shafts, each 5 feet in interior diameter, opening through the roof of the chamber at the end opposite to the outlets. Each shaft is tightly lined with concrete, and is continued down into the chamber by means of a somewhat flaring steel casing to a distance of about 15 inches below the water level. Just beneath, and reaching somewhat into the opening of the casing, is a conical boss of concrete. From water level in chamber through the air and water-tight shaft to the water level at the intake above is 343 feet. This is 72 feet greater than the distance between the water levels at the outlet end, and this difference expresses the available head of water.

*See description and report of test in paper on "A High Duty Air Compressor," by Professor O. P. Hood, *Transactions American Society of Mechanical Engineers*, 1906.

At the intake water is admitted through an annular funnel over a hollow ring from the flat inner periphery of which project 1,800 three-eighth-inch tubes into the annular opening of the funnel. The water must flow over the mouths of these tubes, and in doing so it produces the aspirating effect which entrains the air in small bubbles. The air comes mainly through the tubes from the hollow ring which has suitable intake pipes extending above the water level. The mixed water and air fall through the vertical shaft, and are discharged radially from the annular outlet formed by the concrete boss and steel casing below. The current through the chamber is slow, and the air disengages itself, collecting in the top of the chamber, and displacing the water. By its pressure on the water surface in the chamber it maintains the 271 feet of difference in level between that surface and the one at the discharge of the outlet shaft.

While running at less than full capacity the water level in the chamber is prevented from being depressed further than 14.5 feet from the roof by means of a blow-off pipe, 12 inches in diameter, which opens somewhat below the normal water level. When the water has been pushed down sufficiently air enters this pipe, and its escape relieves the excess of pressure. When the blow-off is in operation the appearance at its mouth greatly resembles the eruption of a powerful geyser. The stream of spray, due to the entrance of water with the air from the chamber, is thrown sometimes to a height of 400 feet.

The capacity when all intake shafts are operating is about 5,000 horse-power. So far but one intake is used. This under test at near its maximum capacity showed an efficiency of better than 82 per cent. while delivering 11,930 cubic feet of air per minute at 128 pounds absolute pressure.

All machinery at the stamp mill and at the mine, whether on the surface or underground, is operated by compressed air. Besides utilizing cheap power the compressor has obvious advantages over the usual machine in the absence of parts to get out of order and in low cost of attendance.*

*See description by A.L. Carnahan in the *Mining World* of August 25, 1906, and by C.H. Taylor in *Mining and Scientific Press*, August 18, 1906.

The foregoing examples are presented to Section D as illustrating the type of problems which are arising in connection with the extensive operations at great depths on the low-grade lodes of the Lake Superior copper district.

## PAPERS READ.

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THE GEOLOGICAL MAP OF NORTH AMERICA. BY BAILEY WILLIS.

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THE ELEVATED BEACHES OF LABRADOR. BY M. L. FULLER.

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THE COLORADO DESERT AND SALTON SEA. BY M. R. CAMPBELL.

SECTION E.

# Geology and Geography.

ADDRESS

BY

# WILLIAM NORTH RICE,

VICE-PRESIDENT AND CHAIRMAN OF SECTION E FOR 1906.

## *THE CONTRIBUTIONS OF AMERICA TO GEOLOGY.*

In speaking of the contributions of America to geology, I do not propose to give an inventory of the geological facts which have been made known as the result of work in this country. An area of three million square miles has been covered by geological reconnoissance, and much of that area has been surveyed in detail. It is, moreover, an area interesting in many respects. It is a country of vast mineral wealth, leading the world in the production of coal, petroleum, salt, iron, copper, silver, and lead, and ranking with Australia and South Africa as one of the three great gold-producing regions of the world. It is a country presenting a remarkable variety of topography and geological structure; and some of its scenic features can be adequately described only in superlatives. It includes vast prairies of great fertility; the Missouri-Mississippi river system, with thousands of miles of navigable waters; the broad and complex mountain mass of the Cordillera; the Great Lakes of the Canadian border, a chain of fresh-water seas; the sublime cataract of Niagara; the remarkable region of interior drainage of the Great Basin; the geysers of the Yellowstone; the cañon system of the Colorado and its tributaries, unparalleled in depth and extent; the lava flood of the northwest, surpassed in area only by that of the Deccan. The exploration of a region so vast and so varied must, of course, have made an important addition to the facts upon which geological science is founded.

Of these facts, however, I do not propose to give even an outline. I propose rather to ask the question, "What has our country contributed to the stock of geological ideas?" In that classical history of geological science which Lyell has given us in his "Principles of Geology," he calls attention to the fact that the share which different nations bore in the early development of geological science was dependent not alone upon the genius of individual workers, but in large measure upon the peculiar geological conditions of the various countries in which they worked. It was in the presence of the varied mineral wealth of the Erzgebirge that Werner laid the foundations of mineralogy and lithology; the magnificent display alike of igneous and of aqueous agencies in the Highlands of Scotland helped to guide Hutton to those theoretical views which were the beginning of modern dynamical geology; the remarkable completeness with which, for an area so small, the series of stratified formations is developed in England, gave William Smith the opportunity to lay the foundations of stratigraphical geology; and the abundant vertebrate fossils in the Paris basin enabled Cuvier to create the science of paleontology. That history of the labors which founded our science in the close of the eighteenth and the beginning of the nineteenth century, suggests the question whether there have been developed any characteristically American ideas in geology.

Of course, it must be admitted that there is to-day no department of geological science which is as characteristically American as mineralogy was German, and dynamical geology was Scotch, and stratigraphical geology was English, and paleontology was French, a century ago. The conditions of life in colonial days and in the early decades of our national history did not afford the opportunity for fruitful scientific investigation. We had no universities, no libraries, no museums, that could be compared with those of the Old World. The conquest of the land from forest and wild beast and savage man, the achievement of national independence, the beginning of the development of national wealth, necessarily preceded the beginning of scientific investigation. When the time came for scientific work in this country, geology had already become a recognized science.

That early stage of incompleteness in which one department was developed here and another there, had passed. It was too late for any country to create a new department in geology. I believe, nevertheless, that there have been certain contributions to the stock of geological ideas which are characteristically American; and that it is not fanciful, in the spirit of that passage of Lyell which I have cited, to connect these characteristically American ideas with our geological environment.

## I. THE PERMANENCE OF CONTINENTS.

Among the early state geological surveys there were two commenced in 1836 which were destined to have in different ways a surpassing influence upon the development of geological thought. Those were the surveys of New York and Pennsylvania. In passing southwestward across New York, from the Adirondacks to the Pennsylvania border, one would traverse substantially the whole series of Paleozoic formations from the Cambrian to the Carboniferous, most of these formations extending across the state in approximately parallel east and west bands. That remarkably complete development of the Paleozoic series made the stratigraphy of New York a standard of comparison for the subsequent study of the Paleozoic strata throughout the eastern United States, as the stratigraphy of England had already become, in its broader outlines, a standard of comparison for the world. But that regular succession of Paleozoic strata from the Adirondacks to the Pennsylvania border was suggestive of a dynamic idea. It suggested a gradual emergence of the land from the waters of the sea. In later years, as geological investigation extended westward, a somewhat similar succession could be traced in the Mississippi basin, southward from the Archæan mass north of the Great Lakes. The doctrine of the permanence of continent and ocean —the gradual emergence of continental lands and the withdrawal of the waters into the deepening ocean basins—was first enunciated by Dana in 1846.* He had just returned from his voyage around the world in Wilkes's exploring expedition. In

*Am. Journal of Science, (2) ii, 352–355.

that voyage he had studied the phenomena of barrier reefs and atolls, had adopted Darwin's theory of their origin by subsidence, and had defended and illustrated the theory by a far greater wealth of observation than Darwin's route had afforded him the opportunity to make. It was, apparently, the thought of the subsiding ocean bottom, rather than the thought of the emerging land, by which Dana was first led to the doctrine of the permanence of continent and ocean; but, in his presidential address before the American Association for the Advancement of Science, in 1855, he refers to the stratigraphy of New York as illustrating the idea of continental emergence. The generation of students who have learned geology from Dana's "Manual" and "Text-book," will remember how prominently he brings forward the succession of Paleozoic formations in New York, as illustrating his conception of the gradual emergence of the land from a continental sea.

The doctrine of the permanence of continents when announced by Dana was essentially a new one. Geologists and pseudo-geologists of all classes had felt at liberty to redistribute continents and oceans according to their own sweet will. After the biblical pseudo-geologists had become convinced of the impossibility of the deposition of the whole series of fossiliferous strata in the Noachian deluge, their next shift was the supposition that the fossiliferous strata had been deposited in the ocean in the interval between the creation and the deluge, and that at the time of the latter event continent and ocean were reversed. Hutton believed that the débris of the continents was carried far out to sea by means of ocean currents, and was deposited over substantially the whole floor of the ocean; and, when one continent was worn away, another might be uplifted in some other part of the world.* Lyell eliminated the catastrophic element of Hutton's theorizing; but, like his predecessor, Lyell believed in an indefinite amount of change in the distribution of continent and ocean. In attempting to find a geological explanation for changes of climate, he felt at liberty to speculate on a series of changes in the distribution of continent and ocean which would sometimes bunch the continents around the

*Playfair, *Illustrations of the Huttonian Theory*, note xix.

poles, and at other times girdle the earth with an equatorial belt of land.* The readers of Darwin's "Letters" will remember his half comic, half pathetic protest, in a letter to Lyell, that the disciples of the great geologist "in a slow and creeping manner beat all the old catastrophists who ever lived."†

There is now little doubt that Dana was right in his general conception. The greater density of the suboceanic masses in comparison with the subcontinental masses, as shown by pendulum observations, indicates that the distinction between continent and ocean has its basis in the heterogeneity of the material in the interior of the earth; and the determining conditions must, therefore, have had their origin in the initial aggregation of that part of the primitive nebula which formed the earth; or, perhaps, as suggested by Chamberlin and Salisbury, in changes attendant upon the beginning of the formation of the ocean. The study of the sedimentary rocks which cover our existing continents shows that almost all of them were deposited in shallow waters; many of the strata, indeed, in waters so shallow that the layers of mud and sand were from time to time exposed by the receding tide or the subsiding freshet, to dry and crack in the sun or to be pitted by raindrops. None of the sedimentary deposits seem to have been formed in waters of truly oceanic depth.

Certain it is, however, that Dana made the evolution of the continents too simple an affair. He recognized, indeed, that the progressive emergence of the continental lands was attended by continual oscillation; yet, even in the last edition of his "Manual," it appears that he did not duly appreciate the magnitude of those oscillations. We now know that in early Cambrian time the Mississippian sea was only a sound or strait, most of the area in which the Trenton limestone was subsequently deposited being then dry land. Only gradually did the Appalachian strait widen out into the Mississippian sea. A true conception of continental evolution must recognize two complementary truths: a wide range of oscillatory movement, and yet on the whole a progressive deepening of ocean basins and a

*_Principles of Geology_, 11th edition, New York, 1872, vol. i, p. 271.
†_Life and Letters_, New York, 1888, vol. i, p. 431.

progressive emergence of continental lands. Chamberlin has formulated the doctrine of an alternation of marine and continental periods due to an intermittently progressive deepening of the ocean basin,* and has connected therewith an ingenious and beautiful theory of climatic changes in geological time.

The doctrine of the progressive evolution of continents, as taught by Dana, gave new clearness and emphasis to the general conception of geology as a history of the globe. Le Conte, in his cordial and generous eulogy of Dana, declared that "geology became one of the great departments of abstract science, with its own characteristic idea and its own distinctive method, under Dana."† There is certainly somewhat of exaggeration in this commendation, yet the statement contains an important truth. More or less clearly, all geological investigators must have felt that the distinctive idea of geology is that the structures of the rocks of the earth's crust have their supreme significance as monumental inscriptions, the deciphering of which may reveal to us the history of the earth. Yet this conception was never before so clearly formulated, and the whole treatment of the subject so consistently adjusted thereto, as in the writings of Dana. The portion of previous manuals dealing with the local distribution of the series of strata had generally borne some such title as "Stratigraphical Geology;" and very commonly, as in the well-known works of Lyell and De la Beche, the series had been traced backward, beginning with the most recent strata. In Edward Hitchcock's "Elementary Geology," with which, in my boyhood, I commenced the study of the science, the stratigraphic chapter bears the title, "Lithological Characters of the Stratified Rocks." It occupies only twenty pages in a book of more than four hundred pages. It traces the formations backward in Lyellian fashion. Separate from the stratigraphic chapter is another and longer chapter on paleontology, which is arranged botanically and zoologically, and not chronologically. The phrase, "Historical Geology," which forms the title of the largest section of Dana's "Manual," involves a distinct clarification of the general view of the science. Start-

*_Journal of Geology_, vi, 449–462, 597–621.

†_Bull. Geological Society of America_, vii, 463.

ing with this conception, he, of course, dealt with the earliest formations first. In the treatment of each era he endeavored to reconstruct, from the evidence afforded by the kinds and distribution of the rocks, the physical geography of the time. The subdivisions of that chapter of the "Manual" are characterized, not as series, systems, and groups of strata, but as eras, periods, and epochs of time. The common use, in recent geological writings, of such phrases as "Silurian era," rather than "Silurian system," etc., is a testimony to the influence of Dana's mode of treatment.*

## II. THE THEORY OF MOUNTAIN-MAKING.

The Geological Survey of Pennsylvania, to which I have already referred, made known the folded structure—the alternate anticlines and synclines—of the Appalachians. The beautiful sections of these folded strata, in the Atlas of that survey, reveal the thoroughness with which the structure of the mountains was investigated by Henry D. Rogers; and can be studied with delight to-day, in spite of the fantastic nomenclature which the student has to translate into the familiar language of the New York Survey. In those sections it appears that, in general, each fold is unsymmetrical, the dip on the northwest side being steeper than that on the southeast, if, indeed, the dip on the northwest side is not carried beyond the perpendicular and reversed. While in each fold, as a rule, the dip is steeper on the northwest side than on the southeast, if we compare the successive folds, we find the dips growing more gentle as we go from southeast to northwest. The nearly vertical or overturned dips of the folds on the eastern border pass by a gradual transition into gentle undulations on the western border of the Appalachian zone.

While the stratigraphy was worked out so beautifully in the first Geological Survey of Pennsylvania, the dynamic conception derived from it was crude indeed. The conclusions of the author are summed up in the following sentences: "The wave-like structure of undulated belts of the earth's crust is attributed to

*H. S. Williams, in *Journal of Geology*, iii, 606, 607.

an actual pulsation in the fluid matter beneath the crust, propagated in the manner of great waves of translation from enormous ruptures occasioned by the tension of elastic matter. The forms of the waves, the close plication of the strata, and the permanent bracing of the flexures, are ascribed to the combination of an undulating and a tangential movement, accompanied by an injection of igneous veins and dykes into the rents occasioned by the bendings. This oscillation of the crust, producing an actual floating forward of the rocky part, has been, it is conceived, of the nature of that pulsation which attends all great earthquakes at the present day."* The wave-like form of the Appalachian anticlines and synclines is a beautiful generalization of accurate and conscientious observation; but the dynamic theory suggested for its explanation needs to-day no other refutation than its simple statement.

But, however completely the Pennsylvania geologists failed to construct a satisfactory theory of mountain-making, their observations of Appalachian structure were of immense value in their destructive effect upon some of the notions of mountain-making prevalent at the time. In the text-books in the early part of the nineteenth century, a diagram often appeared representing a transverse section of an ideal mountain range.† A vertical wall of crystalline rock forms the center and the crest of the range. Against this wall, on each side, the oldest strata lean in a nearly vertical position; farther from the center, strata of less antiquity lean with more gentle dips against the steeper and older strata; and finally, on the flanks of the mountain range, still newer strata rest nearly horizontally. The diagram represents a dislocation of the strata by repeated vertical upthrusts of the crystalline core. Of course, it was seen at once that there was nothing common to these ideal sections and the real sections of the Appalachians revealed by the Pennsylvania Survey. The billowy form of the Appalachian folds meant something, and something very different from the prevalent conception of mountain ranges.

The true interpretation of the Appalachian waves is probably

*Geology of Pennsylvania*, vol. ii, pt. ii, p. 916.

† Hitchcock, *Elementary Geology*, 30th edition, p. 191.

to be found in the contractional theory of mountain elevation, of which Dana was the leading expounder. The views of Le Conte on the subject of mountain-making were in most respects similar to those of Dana. But, while Le Conte's discussions were of great value, the priority in the general development of the theory belongs to Dana. "To the North American geologists," says von Zittel, "undoubtedly belongs the credit of founding the theory of horizontally acting forces and rock-folding upon an ample basis of observation."*

That the main cause of mountain elevation is tangential pressure in the crust resulting from internal contraction, is now generally acknowledged, though there may be doubt whether the main cause of contraction is the cooling of the earth from an incandescent condition, as assumed in the commonly accepted form of the nebular theory, or the gravitational adjustment of an incoherent mass of planetesimals, as assumed in the more recent hypothesis of Chamberlin and Moulton.

The idea of the contractional origin of mountains was not, indeed, original with Dana. There was a glimmer of the idea in the writings of Leibnitz, and Constant Prévost developed the idea into a definite scientific theory; but the elaboration of the theory into its present form we owe chiefly to Dana. His discussion of the subject began in the *Journal of Science*, in 1847. In later years he returned to the subject again and again; and the theory, as shaped by his maturest thought, appears in the last edition of the "Manual." In his earlier writings his views of the origin of continents and mountains were developed on the assumption of a liquid globe. In later years he abandoned that view and adjusted his theories to the more probable doctrine of a globe substantially solid.

The conception of the subsidence of the suboceanic crust, which led Dana to his views of the permanence of continent and ocean, is an important element in his theory of mountain-making. In the contraction of the earth's interior, the suboceanic crust necessarily flattens in its subsidence, so that its section continually approaches the chord of the arc, thus exerting a tangential thrust toward the continental areas. The rather abrupt

*History of Geology and Palæontology*, p. 307.

change in the radius of curvature in passing from the oceanic to the continental areas, makes the continental borders lines of weakness which determine in general the location of the great mountain wrinkles. In the two continents of North and South America, with their mountain borders on the east and west and their vast interior plains, Dana found exemplified the typical continent. Their isolated situation seemed to allow a more typical development than was possible in the Old World, where continents are massed together; as the laws of crystalline form can exhibit themselves in perfection only where a single crystal in a solution or magma is allowed to grow without interference from other growing crystals.

According to the vews of Dana and Le Conte, mountain ranges have been only exceptionally developed by geanticlinal uplifts of the earth's crust. A mountain range, in general, has its birth in a geosyncline—a downward folding of the crust, forming a trough, in which sedimentation goes on *pari passu* with the subsidence. At length, after long ages of subsidence and sedimentation, the strata in the trough are crushed together into alternate anticlines and synclines, or one part is forced over another in great thrust faults, while slaty cleavage and more decided metamorphism may be produced. The mountain range thus produced Dana called a "synclinorium," while he suggested the name "anticlinorium" for a mountain range formed by a permanent geanticlinal elevation.* Apparently the actual history of most mountain ranges is complex. The Appalachian range, for instance, was formed as a synclinorium at the close of the Paleozoic, degraded nearly to base-level in Mesozoic time, and again elevated by a broad geanticlinal movement early in Cenozoic time. It represents, therefore, in its complex history, Dana's two types of the synclinorium and the anticlinorium.

There are unquestionably weak points in the theory of mountain-making as developed by Dana and Le Conte; and, in our ignorance of the conditions in the interior of the earth, and of the forces there in action, it ill becomes us to be dogmatic; but the contractional theory seems worthy of provisional acceptance

*Am. *Journal of Science*, (3) v, 432.

as the most plausible explanation of orogenic movements yet suggested.

### III. GLACIAL GEOLOGY.

Surely no part of the world affords better opportunity for the study of glacial geology than America. Its ice sheet, four million square miles in area, far exceeds any of the ice sheets of the Old World. The imbricated sheets of till in the Mississippi Valley afford clear evidence of the complex series of glacial and interglacial epochs. The driftless islands in the vast area of till, and the interlobate moraines, show the division of the marginal portion of the ice sheet into lobes determined by the topography. The old beaches along the shores of the Great Lakes, the living Niagara, and the various extinct Niagaras,* record the stages of the melting of the ice. The Malaspina Glacier affords illustrations of the formation of eskers and of other phenomena which must have marked the stagnant margin of the waning ice sheet. Surely our country affords most favorable conditions for the study of the history of the Glacial period.

It is a curious fact that the first published suggestion of the agency of ice in connection with the drift came from a cotton manufacturer in Connecticut, Peter Dobson by name. In the *American Journal of Science*, in 1826, he gives a very clear and satisfactory description of the glaciated boulders observed in the drift, and gives as his conclusion: "I think we can not account for their appearances unless we call in the aid of ice along with water, and that they [the boulders] have been worn by being suspended and carried in ice, over rocks and earth, under water."† It was his idea that these boulders were lifted from the bottom of the sea by sheets of anchor ice. This theory was certainly more satisfactory than most of the theories in vogue before that time, and more satisfactory than many of the opinions held at a later date.

The credit of the introduction and championship of the glacier theory of the drift belongs, not to a native, but to an adopted citizen of this country. Louis Agassiz came to this country in

*E. g., those at Jamesville Lake and Blue Lake, near Syracuse.

† *Am. Journal of Science*, (1) x, 218.

1846. In his early home in Switzerland, he had already adopted the belief of Venetz and Charpentier in the former great extension of the Alpine glaciers, and their agency in the transportation of blocks from the Alps across the Swiss lowland to the Jura. It is, indeed, a curious fact that these Swiss geologists were anticipated, in the conception of the transportation of these blocks through the agency of glaciers, by Playfair, who suggested the idea in 1802.* In the early papers of Agassiz the conception of the Glacial period took a form which he himself later recognized as an exaggeration. He conceived at first of a fall of temperature so wide-spread and so extreme that a polar ice cap extended southward over the whole breadth of Europe and across the Mediterranean, reaching the Atlas Mountains. Later he recognized the ice sheet that covered the Alps as entirely separate from the ice sheet of northern Europe. The tendency to an exaggerated view of the Glacial period overcame him again in later years, when he maintained that, at the climax of the Glacial period there was "floating ice under the equator, such as now exists on the coasts of Greenland."† Incidentally, he based upon this extravagant conception of the Glacial period an argument against Darwin's views of the origin of species, maintaining that the wide-spread cold of the Glacial period produced a general extermination of life, necessitating a new creation. But the extravagance of some of his conceptions, and his vain attempt to stop the resistless progress of the doctrine of evolution, may well be forgiven, in memory of the great service which he rendered in bringing into general acceptance the glacier theory of the drift.

As Agassiz traveled in various parts of his adopted country, he recognized everywhere in the northern states the traces of glaciation, already familiar to him in Switzerland and in Scotland; and his views found more ready acceptance in this country than in some of the countries of Europe. Guyot, who had been associated with Agassiz in the study of the glaciers of Switzerland, came to this country in 1848; and he was, of course, a strong ally in the defense of the glacier theory. As early as

* *Illustrations of the Huttonian Theory*, p. 388.

† *Life and Correspondence*, vol. ii, p. 639.

1841 Edward Hitchcock had been so strongly impressed by the writings of Agassiz that he recognized clearly the traces of glaciers in Massachusetts; and, in his presidential address before the Association of American Geologists, and in the postscript to his "Final Report on the Geology of Massachusetts," he shows himself almost persuaded to adopt the glacier theory for the explanation of the drift in general. He could not, however, quite bring himself to the acceptance of the conception of a glacier capable of moving with so little slope as to be able to transport material southward over the whole of northeastern America; and he accordingly limited the action of glaciers to those cases in which the drift appeared to be dispersed somewhat radially from local centers in mountainous or hilly regions. The general southward movement of the drift seemed to him to require the conception of submergence of the land, and transportation by icebergs floating southward from the Arctic regions.* As early as 1852, one of the best and most popular text-books of the time, that of Gray and Adams, gave the preference to the glacier theory of the drift. Dana, in his presidential address before the American Association for the Advancement of Science in 1855, manifestly inclined to the glacier theory; and, in the first edition of his "Manual of Geology," in 1862, he gave his adhesion more decidedly to that view. The next generation of American students of geology were brought up on the various editions of Dana's "Manual" and "Text-book," so that thenceforward the glacier theory was recognized in this country as orthodox. In some of the countries of Europe the theory of submergence and transportation of boulders by icebergs held the ground longer. In 1864 Lyell still maintained the submergence of the plain of northern Europe, and of the glaciated region of North America;† and it was not until 1875 that Torell, in a memorable meeting of the German Geological Society, convinced the German geologists that the drift of northern Germany was transported by an ice sheet whose center was in the mountains of Scandinavia, and the name Diluvium, though still used

* *Illustrations of Surface Geology*, p. 71, *Smithsonian Contributions to Knowledge*, vol. ix.

† *Elements of Geology*, 6th edition, London, 1865, pp. 149, 164.

in German geological writings, was completely emptied of its original connotation.*

Within the last few decades the labors of a large number of earnest and able investigators have developed the glacier theory more in detail, and have added vastly to our knowledge of Quaternary history. The imaginary polar ice cap has given place to ice sheets of more limited dimensions, though still vast, developed respectively about the Laurentide, Keewatin, and Cordilleran centers. The series of terminal moraines, marking stages of readvance or halts in the retreat of the ice sheet, have been carefully mapped. From the experience gained in the study of terminal moraines in this country, Lewis was enabled, in 1886, to recognize and interpret the terminal moraines of the ice sheet in England; and Salisbury, in the following year, those of north Germany. The recognition of interlobate moraines and of driftless areas led to a clearer understanding of the nature of the movement of the great ice sheet. The driftless area of Wisconsin was noticed by J. D. Whitney as early as 1862, and has been more carefully studied by Chamberlin and Salisbury; and the latter investigator has called attention to a smaller driftless area in Illinois. The Quaternary period, instead of being brief and comparatively simple, has been shown to be of long duration and great complexity. It has been analyzed into a succession of glacial and interglacial epochs; and, from the vast amount of erosion in some of the interglacial epochs, it has been inferred that post-Glacial time is very short in comparison with inter-Glacial time. The history of the series of lakes held between the front of the receding ice sheet and the southern watershed of the Saint Lawrence basin, has been studied by Gilbert, Taylor, Fairchild, and others. In Chamberlin's theory that the cause of the Glacial climate is primarily the diminution of the amount of carbon dioxide in the atmosphere, and that the location of the main centers of glaciation is due to the path of cyclonic storms, we have a theory which, if it can not be accepted with full confidence as the true one, is at least the only theory of the Glacial climate which has not yet been weighed in the balance and found wanting. There seems still to be some dis-

* von Zittel, *History of Geology and Palæontology*, p. 232.

agreement among physicists on the critical question, what effect small changes in the amount of carbon dioxide in the atmosphere would produce upon the climate. The views of Arrhenius, upon which the theory of Chamberlin is based, have been contested by Ångström* and Very,† and are not accepted by Hann.‡ If the physicists can be brought to an agreement on this fundamental point, we may feel that we have, at last, a theory of the Glacial climate. The alternative at present seems to be the acceptance of Chamberlin's theory, or the confession that we have as yet no explanation of the Glacial climate.

## IV. SUBAERIAL DENUDATION AND THE EVOLUTION OF DRAINAGE SYSTEMS.

In early years the study of geology in this country was substantially confined to the region east of the Mississippi; but, in due season, the weird and fascinating region of the Cordillera revealed itself to explorers and geologists. It is now more than half a century since American geologists began the study of that western wonderland. The earliest geological work was done in connection with expeditions undertaken for other purposes, as the Pacific Railroad explorations, which commenced in 1853, and Ives's Colorado expedition. It is, however, forty years since the national government established geological surveys in that western country. A period of a dozen years commencing with 1867 was marked by the achievements of four great organizations devoted specifically to geological work—the Survey of the Fortieth Parallel, the Survey West of the One Hundredth Meridian, the Survey of the Territories, and the Survey of the Rocky Mountain Region. Since 1879 all these organizations have been superseded by the United States Geological Survey. A new world for geologists was that weird western land—that land of deserts, plateaus, and cañons, with vast stretches of almost horizontal stratification broken by faults and monoclines, revealing its geological structure with wondrous clearness by reason of an arid climate whereby it has

* *Annalen der Physik*, (4) iii, 720–732.

† *Bulletin G, Weather Bureau, U. S. Department of Agriculture.*

‡ *Handbook of Climatology*, pt. i, p. 399.

been left naked and destitute of any mantle of soil and vegetation. There is revealed, as nowhere else in the world, the power and the method of subaerial denudation. The Grand Cañon of the Colorado is a stupendous object lesson of erosion; and, if one is compelled to recognize river erosion in the cañon itself, scarcely less strenuous is the compulsion to recognize subaerial denudation in the vast platform of Carboniferous strata with little outlying buttes of Permian and later formations. The study of that country has been fruitful in its contributions to the knowledge of aqueous agencies in dynamical geology. Very early appeared those three monumental works: Powell's "Exploration of the Colorado River," Gilbert's "Geology of the Henry Mountains," and Dutton's "Tertiary History of the Grand Cañon District." The value of those early studies in a new field is not greatly lessened if some conclusions must be modified by later study. It may be that the course of the Green River through the Uinta Mountains is not a typical case of antecedent drainage; and it seems certain that the esplanade in the Kanab section of the Grand Cañon is not due to a long pause in the movement of elevation, in which the river nearly attained base-level:* but the conceptions introduced into dynamical geology as the result of those early studies are no less valuable and fruitful.

The first lesson that geologists learned in that western land was the efficiency of subaerial denudation—the power of atmosphere, rain, and river to remove vast quantities of material, and shape the topography of wide areas. From Hitchcock's "Elementary Geology" I learned in my boyhood, in regard to cracks and fissures in the strata, "If the fissure is open and of considerable width, it is called a gorge; if it be still wider, with the sides sloping or rounded at the bottom, a valley is produced."† Hitchcock was convinced, indeed, that the Niagara gorge was due to erosion; but he declared that the gorges of the Connecticut between Mount Tom and Mount Holyoke, and below Middletown, could not be due to the action of the river, and that the gorges of the same river at Bellows Falls and Brattleboro were

*Davis, in *Bull. Museum of Comparative Zoology*, xxxviii, 180–186.
†*Op. cit.* p. 39.

too wide to have been formed by the river alone.* In his "Illustrations of Surface Geology," in discussing the criteria by which to distinguish fluviatile from oceanic work, he declared: "Rivers have little power to form wide valleys."† Apparently geologists were confused with a vague idea that the ocean is bigger than the rivers, and that, therefore, it can do more work in erosion. As early as 1847, Ramsay had recognized that the summits of the mountains of Wales were remnants of a former plain of erosion, but he conceived of it as a "plain of marine denudation," and that phrase holds its place to-day in English writings. With genuine British loyalty and convervatism, Sir Archibald Geikie retains the phrase even in the latest edition of his "Text-book," in explanation of table-lands of erosion; though, even in his earliest edition, he declared that, in the production of plains of marine denudation, "the sea has really had less to do than the meteoric agents. A plain of marine denudation is that sea-level to which a mass of land has been reduced mainly by the subaerial forces."‡ He attributes to ocean waves and currents only "the last touches in the long process of sculpturing." Elsewhere Geikie bears emphatic testimony to the influence of American geologists, in the words: "Unquestionably the most effective support to Hutton's teaching has been given by the geologists of the United States, who, among the comparatively undisturbed strata of the western territories, have demonstrated, by proofs which the most sceptical must receive, the potency of denudation in the production of the topography of the land."§ It is, indeed, marvelous with what prophetic vision Hutton and Playfair conceived some of those ideas of river action which the geologic world in general learned only from the work of American geologists in the Cordilleran region.‖ On this subject, those two Scotchmen were a half-century in advance of their time.

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* *Op. cit.*, pp. 215, 227.

† *Op. cit.*, p. 90.

‡ *Text-book of Geology*, London, 1882, p. 451. In later editionst he phrase "base-level of erosion" is substituted for "sea-level."

§ *The Founders of Geology*, 1st edition, p. 181. The passage is somewhat modified in the later edition of the work.

‖ Playfair, *Illustrations of the Huttonian Theory*, note xvi.

That western land has taught us not only to recognize the fact of subaerial denudation, but also to formulate its methods. In Powell's "Exploration of the Colorado River," he distinguished rivers as consequent, antecedent, and superimposed. Davis has carried the analysis somewhat further, giving us subsequent and obsequent rivers. Powell formulated the doctrine of base-levels; Davis has given the conception greater accuracy and consistency by distinguishing base-level from profile of equilibrium. The base-level of a district is a portion of the ideal spheroidal surface of the earth. Disregarding the curvature of the earth's surface, base-level may be represented in profile as a straight line; profile of equilibrium as a curve, concave upward, tangent to base-level at the mouth of the river, gradually approaching base-level with the progressive denudation of the country, but never quite reaching it except at the point of tangency. To Davis also we owe the full development of the conceptions of youth and age in river valleys and in drainage systems, and of cycles of erosion ending in the formation of peneplains. We have learned to search in every rugged mountain region for remnants of ancient peneplains. We have learned, in general, that geological history is to be read, not only in deposits, but also in erosion forms.

## V. TERTIARY MAMMALS AND THE DOCTRINE OF EVOLUTION.

Half a century ago the exploring expeditions connected with the Smithsonian Institution began to collect fossils from the Tertiary deposits of the western plains. Later the work was followed up by the Geological Surveys under the auspices of the national government, and by numerous private expeditions under the auspices of universities, scientific associations, and individuals. Over those western plains were found to stretch vast continental deposits, certainly not all of lacustrine origin, as at first reported, but in part piedmont alluvial formations, in part eolian deposits, and, in limited areas, deposits of volcanic dust. These continental deposits of the western plains yielded in unparalleled richness mammalian fossils, which have been studied by Leidy, Marsh, Cope, Osborn, Scott, Wortman, and

others. No other single series of discoveries has been so potent in changing the bearings of paleontology upon the doctrine of evolution.

In Darwin's two chapters on geology in the "Origin of Species," he marshaled with great skill the geological facts then known which appeared favorable to evolution. Yet he recognized in the facts of paleontology "perhaps the most obvious and serious objection which can be urged against my theory."* He cited a long list of recognized authorities in geology and paleontology, still living or recently dead at the time of the publication of his first edition, who were believers in the immutability of species—Cuvier, Agassiz, Barrande, Pictet, Falconer, Forbes, Lyell, Murchison, Sedgwick. Of these Lyell alone lived to become a convert to evolution.

Of course the objection which Darwin felt so strongly himself and which seemed conclusive to so many paleontologists at the time, was the absence of gradation between different forms. The theory of evolution, and especially the strictly Darwinian form of that theory, requires fine gradation between species—not indeed between different species now existing, but between existing species and species now extinct, and between fossil species of successive periods. In general, such gradations do not appear. Fossil species are about as sharply defined as recent ones; and whole groups of species—orders, classes, sub-kingdoms—have appeared without recognizable ancestry. Darwin's answer to this objection was given in the phrase now become classical, "the imperfection of the geological record."

In the half-century since the publication of Darwin's first edition, the attitude of paleontologists has completely changed. Not only is it true at present that paleontologists are substantially unanimous in accepting the doctrine of evolution; but it has come to be generally believed that the very science which afforded a half-century ago the strongest objection to evolution now affords its strongest support. This change is in large part due to the discoveries which have so shattered the objection that once appeared so strong. Innumerable links then missing have been brought to light. Intermediate

*Origin of Species, 4th (English) edition, p. 340.

forms between orders and classes formerly supposed to be widely separated from each other have been discovered in great abundance. Numerous series of genera may be traced through successive geological periods, exhibiting a gradually progressive change which almost irresistibly suggests to the mind the belief that the series are truly genetic. The fossils of our western plains have afforded a goodly share of the most important of these new evidences of evolution.

When the first edition of the "Origin of Species" was published, the classes of birds and reptiles seemed to stand widely asunder. But in the very next year (1860) an odd feather of Archæopteryx was discovered, and a year later the skeleton now preserved in the British Museum. But Archæopteryx was a solitary representative of the birds of markedly reptilian character until the discovery of Ichthyornis and Hesperornis in the Cretaceous of Kansas, of which preliminary descriptions were published by Marsh in 1872. Both these remarkable types show reptilian affinities, in the possession of teeth, in the structure of the skull (though unhappily the palatal region is but imperfectly known), and in the pelvis; and Ichthyornis very notably in its slightly biconcave vertebræ, contrasting strongly with the saddle-shaped articulating surfaces of the vertebræ of modern birds. However strongly these genera suggest the idea of an evolutionary connection between reptiles and birds, their own place in the evolutionary series is not easy to determine. Ichthyornis may be in or near the direct line of descent from Archæopteryx to some such generalized dromæognathous type as is represented by those curious living fossils, the Crypturi, from which divergent lines of evolution may have led, on the one hand to the ostriches and other flightless Dromæognathæ, and on the other hand to the Carinatæ. Hesperornis, a degenerate and in some ways highly specialized form, stands certainly at the end of a side branch, and has left no descendants.

But the discoveries of most evolutionary significance, as already intimated, have been among the Tertiary mammals. A number of series have been traced, leading from generalized types in the Eocene, through forms of gradually increasing specialization, to genera which still survive. The first of these

genetic series to be brought to notice was the genealogy of the horse, as traced by Marsh in 1874. Marsh's views were adopted by Huxley in his brilliant "American Addresses," and thereby gained a larger share of public attention than they would otherwise have received. Probably no single fact or group of facts brought to light since the appearance of the "Origin of Species" has been so influential in bringing the theory of evolution into general acceptance. The genealogy of the horse has been corrected in detail and completed by later investigations. The line of descent may now be traced through Hyracotherium and Eohippus of lower Eocene, Protorohippus and Orohippus of middle Eocene, Epihippus of upper Eocene, Mesohippus of Oligocene, Anchitherium of lower Miocene, Parahippus, Protohippus, and Pliohippus of middle and upper Miocene, to Equus of Pliocene and Quaternary; while side branches lead to Hipparion, Hippidium, and other forms which have died without issue.*

A similar series, though with not quite so fine gradations, reveals the genealogy of the camel. From the Eocene Protylopus this line is traced, through Oligocene Poebrotherium, to Miocene Procamelus, whence one branch leads to Camelus, and the other to the South American Auchenia. It is indeed remarkable that the characteristically old-world types, Equus and Camelus, should have been evolved in North America and have become extinct in this their original home. Another series, beginning in the lower Eocene Systemodon, ends in the modern tapirs.

In like manner, among the very primitive carnivores which have been classified as the order Creodonta, the ancestors respectively of the dog and the cat have been recognized in the Eocene genera Vulpavus and Palæonictis.

Of extraordinary interest in an evolutionary point of view is the most primitive Tertiary fauna from the Puerco beds discovered by Cope in 1880. In that fauna is found the culmination of the Multituberculata, which made their first appearance in Triassic time, and whose teeth reveal their close relation to the Monotremata. But, with those survivals from Mesozoic time, appear generalized and primitive forms of placental mam-

*Matthew, in Supplement to *American Museum Journal*, vol. iii, no. 1.

mals, wherein may be traced the ancestry of mammalian groups of later Tertiary and recent t me. Hemiganus and Psittacotherium may be recognized as the ancestors of the Edentata. And, among the most primitive and generalized ungulates, the Phenacodontidæ, Protogonodon has been recognized as possibly the ancestor of the Artiodactyla, and Euprotogonia with more probability as the ancestor of the Perissodactyla.

In the American Museum, where some of our sessions are to be held, the evidence of these genetic series running through the Tertiary is placed before our eyes with incomparable fullness. As we behold the unparalleled richness of those collections, we do not wonder that not even a call to be the official head of the army of science in this country could induce Professor Osborn to leave the Museum which is at once the monument of his work in the past and the material for his work in the future.

But, however numerous are the gradational forms which have been brought to light, Darwin's principle of the imperfection of the geological record is in no wise superseded. It still remains true that the theory of evolution must stand or fall according to our judgment of the adequacy of that principle of Darwin. If the fossils accessible to observation and collected in our museums afford an approximately complete representation of the life that has existed in past ages, there is certainly no standing-ground for any theory of evolution. But, while we have seen numerous chasms bridged by series of gradational forms, we have also come to a fuller appreciation of the significance of Darwin's principle of the imperfection of the geological record.

In the conclusion of Darwin's chapter on the subject, he used a striking illustration: "I look at the natural geological record as a history of the world imperfectly kept and written in a changing dialect. Of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved; and of each page, only here and there a few lines." In the light of our present knowledge of geological history, we are able to see that even this striking illustration fails to do full justice to the subject. The imperfection of the record consists not merely in the fact that some of the chapters are missing. It appears most strongly

when we inquire just what chapters are missing. In the conception of continental history to which I have already referred, we have come to recognize a truth which, in somewhat distorted form, found expression in the old catastrophism. We have come to recognize that comparatively short periods of rapid geographical change alternate with long periods of relative stability or slowly progressive change. This is, in substance, the doctrine of critical periods as formulated by Le Conte.* It is precisely in those critical periods that the record fails, and the gap is indicated by unconformability. Darwinians and Lamarckians alike must recognize that the periods of rapid geographical change must be the periods of most rapid change in fauna and flora. Evolutionary change must be directly or indirectly the result of a failure of adjustment between organism and environment.

The doctrine of critical periods has taken somewhat more definite form in Chamberlin's discussion of the effects of intermittent subsidence of the ocean bottom. The critical periods in geological history are the times when the rigidity of the crust yields to accumulating strain, when the ocean bottom subsides, when the continents emerge to larger area and higher altitude, when more or less of mountain-making takes place, and when the geographical changes bring in their train the diminution of the atmospheric supply of carbon dioxide and a tendency to cold and arid climates. Then come the long periods in which the continents are slowly denuded, the continental shelves are extended landward by encroachment of the sea and seaward by sedimentation, the quota of carbon dioxide is slowly replenished, and the fauna and flora which had been impoverished gradually expand to their former luxuriance. The chapters which are lost from the record are precisely the chapters which would contain the story of those critical periods marked by extinction of manifold species, and by rapid change in adjustment to new and more rigorous conditions. The geological record of the progress of life is like a history of the United States, in which, among other less important chapters, the chapters on the Revolution and the Civil War are lost.

* *Am. Journal of Science*, (3) xiv, 99–114.

## CONCLUSION.

I have not attempted to give a history of geological investigation in this country. Of the great number of earnest and able investigators whose names illustrate the scientific history of this country—of those who have finished their work, but whose memory and influence can never die—of those still living whose achievements in the past are only the promise of greater work in the future—I have named but few, though many others are equally worthy. Of the men whose names I have mentioned, I have doubtless not in all cases mentioned the work which has been most meritorious or important. I have mentioned only those investigations which have a bearing on a few special subjects. Nor have I referred, except occasionally and incidentally, to the work of European students which has gone on parallel with that of students in our own country. American geologists have had no patent rights giving them a monopoly of any particular department of investigation. The limited time of such an address as the present renders impossible a critical discussion of the precise share in the study of the various subjects which belongs to American geologists. But I believe it may be fairly claimed that on the five subjects which I have discussed—the permanence of continents, the theory of mountain-making, the history of the Glacial period, the laws of subaerial denudation, the evolution of mammalian life—the work of American geologists has been relatively so important that the results deserve recognition as, *par excellence*, THE CONTRIBUTIONS OF AMERICA TO GEOLOGY.

## PAPERS READ.

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THE DETRITAL FLANKING SLOPES OF THE MOUNTAINS OF THE SOUTHWEST. BY WILLIAM P. BLAKE, NEW HAVEN, CONN.

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PERSPECTIVE VIEW OF THE SUBMARINE CANYON OF THE HUDSON RIVER. BY J. W. SPENCER, WASHINGTON, D. C. (Abstract not received.)

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EURYPTERUS FAUNA OF THE SHAWANGUNK GRIT. BY JOHN M. CLARKE, ALBANY, N. Y.

---

KENTUCKY ROCK ASPHALT FOR COMMON HIGHWAYS. BY MALCOLM HART CRUMP, BOWLING GREEN, KY.

---

PORTHEUS MOLOSSUS, COPE, AND OTHER FISHES FROM THE KANSAS CHALK. BY CHARLES H. STERNBERG, LAWRENCE, KANSAS.

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SUBAERIAL EROSION CLIFFS AND TALUS IN THE LOWER DEVONIC OF MICHIGAN. BY A. W. GRABAU, COLUMBIA UNIVERSITY.

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THE NAPLES FAUNA IN MICHIGAN. BY A. W. GRABAU, COLUMBIA UNIVERSITY.

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TYPES OF CROSS-BEDDING AND THEIR STRATIGRAPHIC SIGNIFICANCE. BY A. W. GRABAU, COLUMBIA UNIVERSITY.

THE CUMBERLAND COAL BASIN, NOVA SCOTIA. BY J. EDMUND WOODMAN, DALHOUSIE UNIVERSITY, HALIFAX, N. S.

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CHARLES WILLSON PEALE'S PAINTING.—"THE EXHUMING OF THE FIRST AMERICAN MASTODON." BY ARTHUR BARNEVELD BIBBINS, BALTIMORE, MD.

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ADDITIONAL EVIDENCE OF TROPICAL CLIMATE ON THE MIDDLE ATLANTIC COAST DURING THE LOWER CRETACEOUS. BY ARTHUR BARNEVELD BIBBINS, BALTIMORE, MD.

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GEOLOGY OF CORE BANK. BY COLLIER COBB, CHAPEL HILL, N. C.

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THE LOW-WATER CHANNEL OF THE MISSISSIPPI RIVER. BY ROBERT MARSHALL BROWN.

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WALNUT CANYON, ARIZONA, SECTION COMPARED WITH ROCKS OF SIMILAR AGE IN THE TERRITORY. BY H. W. SHIMER.

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STRUCTURAL CONTROL OF SURFACE FEATURES IN THE HIGHLANDS OF THE HUDSON. BY CHARLES P. BERKEY.

---

THE OCCURRENCE OF DIAMONDS IN NORTH AMERICA. BY GEORGE FREDERICK KUNZ.

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A LOWER-MIDDLE CAMBRIAN TRANSITION FAUNA FROM BRAINTREE, MASS. BY H. W. SHIMER.

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NOTES ON THE UPPER AUBREY OF NORTHWESTERN ARIZONA. BY H W. SHIMER.

SECTION F.

# ZOOLOGY.

# ADDRESS

BY


## HENRY B. WARD,

VICE-PRESIDENT AND CHAIRMAN OF SECTION F FOR 1906.


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## *THE INFLUENCE OF PARASITISM ON THE HOST.*

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The line of development within the field of zoological research has shown a distinct tendency within recent years to move in the direction of biological study, to view the organism as a living thing and to seek an explanation for the various problems of life which present themselves in connection with it. One of the earliest phases of biological study found its origin in the condition presented by parasitism. The class of Helminthes, or intestinal worms, of the earliest authors, was seen early in the course of morphological study to be unwarranted as a systematic grouping. The animals included under the term were not those which were in any genetic sense related to each other. Like the earlier designations of land animals and water animals, these forms were grouped together by virtue of similarity in conditions of existence. The term is accordingly a biological one and its purely biological significance was stoutly maintained as early as 1827 by the great embryologist, Carl Ernst von Baer, and by F. S. Leuckart. The idea received finally due acceptance through the efforts of Carl Vogt, who dissociated the earlier group and united its subdivisions with those free living animals to which they were most closely morphologically connected. Even thus early it was apparent that parasitic animals were derived from free living forms, that they were in fact but degraded members of the same groups; in some cases with such little modification in structure that

their affinities were recognized at a glance; in other cases, however, the excessive modification had carried the parasitic form very far from the ancestral type, and yet the existence of a large number of intermediate stages suggested at once that these changes had been gradual. (Van Beneden, 1876.)

In spite of the fact that these studies were among the very earliest of biological investigations, it appears that the reciprocal influence has rather generally escaped discussion. It is my desire accordingly, in so far as may be practicable within the limits of time and space of a single address, to set before you the main facts in connection with this other side of parasitism—the influences which are exerted upon the host animal, the changes wrought in it, and the part they play in the problems of general biology. There is a vast amount of information in detail regarding individual species; and in some cases the relations have been investigated with great care from the standpoint not only of the morphologist and of the physiologist, but even also from that of the chemist; but in the main these observations stand as isolated and unrelated facts. I have neither the knowledge nor the ability to bring them all together into a concrete whole, but there are certain general headings under which it is possible without especial effort or explanation to group some of the phenomena, while others must wait for better knowledge or clearer perception than I possess before they can be included in any generalizations.

In rough fashion it is the custom to class parasites as harmful and harmless. The harmful forms induce pathological changes, stand in some definite relation to disease, and become accordingly of prime importance to the investigator in medical fields. The other forms, while spoken of as harmless or without effect, certainly should not be classed as exercising none. With the exception of certain striking instances, especially among those forms which parasitize man, the effects of parasitism are almost unknown, hence they are largely ignored. In the course of time opinions on this matter have changed radically. As I have said in another paper:

"In the belief of the medical profession two hundred years ago there was no disease, real or imaginary, which was not due

to the presence and effect of some kind of parasite. Each ailment had its particular 'worm' in its characteristic location. This was a direct result of the endeavor to reduce every malady to some definite cause, and from a joining of the unknown sickness with the parasites, of which they knew as little. Under the influence of study and of increase in knowledge regarding the parasites, such a theory was seen to be untenable, and the movement in the opposite direction began—a tendency which may be said by this time to have passed its height. In fact, there has prevailed during recent years among the medical men of this country an exaggerated idea of the unimportance of human parasites." This must give way to a proper conception of the pathological significance of these organisms, based upon careful investigations of their actual influence upon the host.

Yet there are some parasites of which it may fairly be said that even careful study has failed to show any manner in which they affect the host. Thus Looss (1894:3) records of a distome (*Heterophyes*) commonly found in the human alimentary canal among Egyptian laborers, that, although present in considerable numbers, most careful scrutiny fails to disclose any influence which it exerts upon the host. This is traceable to the fact that it neither burrows into nor feeds upon the mucous lining of the canal, but contents itself with taking its food from the partially digested contents of the intestine. Inasmuch as the organism is very small, this is evidently a negligible factor in the economy of the host; but even here, as I shall show later, there is the possibility that under some circumstances the organism may become a menace. Again, *Filaria loa*, the African eye worm, lives for many years in the connective tissue of the human body, wandering from point to point, often not far below the skin. In the course of its migrations it does apparently no injury to the host, who is indeed unconscious of its presence until it happens to come into the connective tissue over the surface of the eye-ball. Here it appeals to the sense of sight, and from here it has most frequently been extracted. But in this case again there are swellings which appear from time to time on the surface of the body and which are believed by some to be due in one way or other to this parasite. (Ward, 1906.)

In the group of indifferent bodies we must also included many if not all, of the resting forms, those which, like the blader, worms, or the young trichinæ, are encysted at a given point and which consequently are not to any appreciable extent absorbing nutrition or producing toxic materials. The encapsulated trichina is but a grain of sand, the encysted bladder worm no more than a globule of fat in the tissue. During its entire life in the body the guinea worm does not seem to exercise any influence whatever upon the host organism, until the female appears at the surface and is desirous of securing an opening through which it may discharge the young into the outer world, where they will find conditions for further existence.

These few preliminary statements have paved the way for a somewhat clearer general idea of the factors which determine the degree of influence exerted by the parasite on its host, and the first is evidently the numerical factor. Commonly, the single parasite leaves no effect; it is the multiplication of parasites which is to be feared. Evidently this multiplication will be most serious when it takes place within the host and leads directly to a multiple infection. This is known among the protozoa, where, in at least one host, there is usually a recurrence of generations of the same type, and this feature is so characteristic that Doflein (1901) designates this cycle of the life history as the multiplicative cycle, defining its purpose as being to achieve the multiple infection of the host. There are also some worms among the Nematodes in which the same thing takes place, and by virtue of which the infection of the alimentary canal is enormously increased in direct fashion.

Among most metazoan parasites, however, including all Trematodes, Cestodes and some Nematodes, such is not the case. The eggs of the individual must be transported to the outer world before they can carry out their development, and they reach a new host after a more or less complicated life history which may involve alternation of generations and parasitism in one or more intermediate hosts, so that when the stage comes in which the infection of the first species is possible, it is very unlikely that the original individual will be reinfected. Among such parasites the effects from a single individual are

not serious, and the real danger lies in a multiple infection through the increase in numbers which such a species often experiences in the intermediate host, or within a limited area in the outer world, so that by the taking in of a single external object a large number of parasites may be introduced. Where alternations of generations exist the dangers of the parasitic existence are so great that the number of parasites is kept down. Yet under a favorable combination of circumstances the numbers of a given parasite may be enormously increased and with this the dangers from the species also enhanced.

Naturally, immediately related to the factor of numbers is the question of comparative size. In a general way the effects of a parasite are related to its mass as compared to that of the host, and this will be clearly manifest in the subsequent discussion. From a special point of view, however, this is absolutely untrue and the secondary effects of an individual species may be out of all proportion to its size. This will also receive more detailed discussion at a later point.

Evidently, both of the factors which have just been mentioned are largely relative and distinctly such with regard to the seat of the injury, *i. e.*, the organ of the body which is attacked; thus a parasite may be quite harmless if located in connective tissue, or between the muscle fibers, while if the same specimen were to be located in the brain or in the eye its effect would be very serious. A small organism would pass entirely unnoticed in the alimentary canal, but in the heart or blood vessel, it might well cause serious disturbances, or under certain conditions even the death of the host, so that the pathogenic significance of a parasite depends essentially upon its location.

The effects of a parasite on the host may be roughly classified as mechanical, morphological, and physiological. To be sure, a sharp separation is not possible at all points and frequently the one influence involves concurrently or subsequently such as belong to another group.

Animal parasites, for the most part, produce only local changes, and these are explicable on purely mechanical grounds, or they are structural or functional within limited areas. But physiological influences sometimes manifest themselves as

symptoms of a general disease. Such manifestations ordinarily accompany the multiplication of the parasite within the host or at least its presence there in large numbers.

Many of the effects upon the host produced by parasites may be explained in purely mechanical fashion, and under this heading are included those which produce even some of the more complicated and far-reaching results of parasitic infection through the secondary effects which they induce.

Regarding the parasite as a passive mass, a purely inert body, it may bring about a stoppage of various passageways and thus induce serious consequences for the host. Such an occlusion of a canal may follow under perfectly normal conditions, but more frequently there is something unusual that tends to induce the condition; either that the parasite is in an abnormal location or that some factor enters into its normal habitat to aid in purely mechanical fashion in the stoppage of the passageway. Thus, the accumulation of a group of common round worms into a ball will suffice at times to occlude entirely the alimentary canal, and the worms, tangled and twisted together, stop the passage of food materials and waste. Unless the condition is accurately diagnosed and promptly alleviated by operative means, this stoppage of the canal results in the death of the host. Such has been the result in man in several cases on record and similar instances are more frequent among other hosts. But in one of the more carefully investigated cases (Blanchard, 1899) it was found that the mass of seventy-two ascarids were inextricably tangled together by a long hair swallowed by accident and in some way twisted tighter and tighter through the contortions of the parasites.

The young sclerostomes of the horse live in the large arteries of the abdomen. Their presence in these arteries explains the aneurisms frequent at this point, as they obstruct the vessels and raise the arterial tension behind the points where they have formed a blockade. This induces in a purely mechanical way a distension of the vessels at the region of increased pressure.

Even much more complicated changes in the host may be reduced in final analysis to a mechanical effect. In the case of the Egyptian blood fluke (Looss, 1905: 96–7) the female

goes into the venous plexus of the pelvis to oviposit and the oval eggs which are supplied with a rudimentary spine at one end are carried into the capillaries by the blood current and there gradually work their way through the wall of the alimentary canal, or the urinary bladder, so as to reach the cavity of the organ and to escape from the body. The large numbers of these eggs which are produced fill up the capillaries, interfere with the flow of blood, lacerate the capillary walls and tissues through which they are forced mechanically, until a series of serious changes is invoked in the organs in question. The condition is even more serious when these same eggs chance to be carried about the body of the host by the circulating blood, become entangled in the capillary network at different points and constitute the foci of small emboli. Such may arise in the brain where retardation of the blood current and the resulting emboli are sources of serious danger to the host, since they give rise to brain tumors and may evoke apoplectic symptoms. (Looss, 1905: 83.) The effects produced by such brain tumors of parasitic origin do not differ from those of other tumors or other foreign bodies. All of these effects are at basis mechanical and the same results would apparently be produced by any inert bodies of similar form and number.

One may go still further and call attention to the fact that in some cases it is a mass of embryos which constitute the mechanical influence at the basis of serious changes. Some of the filariæ which inhabit the connective tissue are viviparous and produce countless numbers of embryos; these are carried by the lymph and blood stream all over the body; accumulating, evidently by chance, in considerable numbers at certain points of the lymph vessels, for instance, they act mechanically to produce lymph stasis and dilation of the parts. The long-continued working of this cause will produce an enormous distension of some regions of the body, giving rise to one form of the condition which is known as elephantiasis. (Looss, 1905: 164.)

Another mechanical influence of the passive parasite is traceable to the pressure which it exerts upon surrounding

tissues. In so far as the parasite is stable this pressure will be constant and its effect is of minor consequence; however, whenever the parasite is in a condition of active growth the gradually increasing pressure becomes an important element to consider, but the discussion of this falls naturally under a subsequent heading.

There are certain influences which the parasite exerts that are mechanical, and still are not traceable to it as a mere inert body; they rather are determined by its activity, and yet they properly deserve consideration under this head, for the parasite, though active, is exerting a purely mechanical influence, and one might conceive of the same results following upon the movement of any inanimate object. If the parasite moves about it tends to irritate and inflame or destroy the surface upon which it lies, even though it remains relatively fixed in location and merely twists from side to side. The irritation here will be evidently local and will be due to, or at least emphasized by, the spines or other roughness of the body. It will be also increased if the parasite possesses suckers or other organs of attachment. The delicate mucous surfaces with which the parasite usually comes in contact are of all parts of the body the most susceptible to injury in this fashion, and, as we shall see later, many parasites combine with the mechanical lacerations of tissue by movements and their hold-fast organs, a physiological influence of far-reaching import.

A complicated case which indicates the combined effects of mass and motion, with possibly additional features of a physiological character not yet well understood, is illustrated by the smaller liver flukes of the genus *Opisthorchis*. These species occur in the gall ducts of the liver and there they evoke changes which, though radical, are in general uniform for different species and hosts. (Blanchard, 1901.) As the flukes advance into the finer canals of the liver, the ducts become completely occluded. The first result is bile stasis and consequent dilation of the canal until this acquires considerable size. Both the epithelial and the connective tissue of its wall undergo profound modifications. The epithelium shows

an active catarrhal irritation. The glands manifest considerable hypertrophy. Many new accessory ducts are formed alongside the original one. Among the secondary effects one may note that while the connective tissue proliferates actively and acquires enormous thickness, the liver tissue undergoes granular degeneration as the cells gradually atrophy, thus the functional portion of the organ is gradually replaced by inert tissue. (Bossuat, 1902.) The arrest of the bile is followed by digestive disturbances, and compression of the branches of the portal vein produces venous stasis from which follows naturally the ascites so frequently observed in the course of the malady. Now all of these modifications follow the mechanical stoppage of the duct naturally, though no doubt the effect is increased by the irritation produced by the movements of the parasites. Some investigators hold that the flukes feed upon the mucous lining of the ducts; this is true of other liver flukes, but according to my observations does not apply to *Opisthorchis*.

Parasites, however, not only carry on movements through their natural territory, but they also from time to time indulge in migrations, the causes of which are not clear, but the effects are serious in the extreme.

The extent of such abnormal migrations is well illustrated by *Ascaris lumbricoides*. This form has been known to migrate along evident pathways from the duodenum into the biliary ducts, and liver, where it has induced hepatic abscesses, or into the pancreas with like results, into the larynx and trachea with the result of suffocating the host (Fournié, 1898), into the eustachian tube to emerge from the auditory canal after perforating the tympanic membrane, or even into the frontal sinuses, or the internal angle of the eye. (Maurizi, 1902.)

Such erratic parasites do not always confine themselves to normal passageways of the body. Even where the penetration of tissue is distinctly exceptional, it not infrequently happens that under some unknown stimulus the species brings itself to transgress natural limitations and to open an abnormal communication between regions otherwise entirely separated. Ascarids

have perforated the intestine, penetrating the peritoneal cavity, have come out from abscesses at various points, or have been discovered on the occasion of a post-mortem in the most varied regions of the body. The liver fluke as it feeds upon the hepatic cells may chance to open a small vessel, or the lung fluke may similarly effect an entrance into the circulatory system and either be thus carried into distant and unnatural parts of the body, reappearing in abscesses, and in expansions of the eyelids, or being caught in brain tumors, which sooner or later arouse the disturbances that naturally result from the presence of foreign bodies in that organ. (Looss, 1905: 82.)

The migrations of smaller forms, even though they may be numerous, are not accompanied ordinarily by the same effects as those of larger species, since the orifices they make are sufficiently minute to close immediately after the animal and prevent the secondary effects which are due to such abnormal connections. Thus the minute embryo of tape worms migrate from the alimentary canal to the point of encystment without influencing appreciably the host, and other larvæ migrate through the tissues with such little disturbance that unless the numbers be large the host suffers no inconvenience.

Emphasis should be laid upon the extreme importance in the economy of the host which the secondary effects exert. The abrasion and destruction of surfaces and cells and the opening of abnormal communications is not *per se* of such vital importance as the results which may follow through the admission of bacteria from the canal into the blood and tissues of the animal. It is frequently held that the uninjured mucous surface is resistant to the action of bacteria, and that typhoid and cholera germs must depend to some extent upon diminished resistance, functional or structural, for their original introduction into the tissues of the body. It is certainly true that many pathogenic organisms exist in the alimentary canal without detriment to the host animal, although if permitted to pass into other parts of the body they excite immediately dangerous symptoms The perforations of the intestinal wall by *Ascaris* (Guiart, 1900),

and the escape of such organisms into the body cavity gives at once the conditions for a serious if not fatal peritonitis, and *Ascaris* is not alone in this respect.*

Examples of this can be multiplied, but one will suffice. In the etiology of appendicitis certain factors are regarded as predisposing, others are direct causes of this malady. As early as 1724 Santorini recorded the presence of worms, probably *Trichuris*, in the appendix. Numerous later authors found at necropsies *Ascaris* and trichurids in this organ, as well as calculi containing eggs of *Ascaris* and *Oxyurias*. In 1901 Metschnikoff noted that in several persons who manifested symptoms of an appendicitis when microscopical examination of the feces demonstrated the eggs of *Ascaris* and of *Trichuris*, the administration of a vermifuge effected a cure. He maintained that nematodes were the cause of many cases of this disease and explained the rôle of the parasites as: first, a direct mechanical or chemical action on the appendix and, second, an indirect action by the introduction of microbes into the mucosa. Metschnikoff did not commit the error attributed to him by some authors of regarding all cases of appendicitis as of parasitic origin, but specifically stated that there are certainly appendicites of different origin. Subsequent authors furnished additional evidence of the direct or indirect action of parasites in producing appendicitis (Schiller, 1902), while others, thought admitting the possibility that nematodes may inoculate the intestinal mucosa with bacteria, regarded this as an inappreciable factor in appendicitis

*Piana was the first to note that the migration of *Cysticercus pisiformis* into the liver of the rabbit could introduce bacteria. In two cases of tubercular peritonitis of dog associated with *Dioctophyme renale* in the abdominal cavity Galli-Valerio (1903: 354) advanced the view that migration of the nematode made possible the development of the bacillus or carried it into cavity. It has recently been clearly shown that the pin worm, *Oxyurias*, has burrowed into the wall of the canal and produced there microscopic ulcerations, while it seems probable that it has actually made its way through the wall into the cavity of the pelvis (Vuillemin, 1902). This perforating action places *Oxyurias* also in the ranks of parasitic introducers of bacteria.

since their presence in this organ constitutes a pathological rarity.*

Evidently in producing ulcerations of the intestinal mucosa parasites facilitate the absorption of toxins from the canal and permit the inoculation of this layer with pathogenic bacteria from the intestinal contents. (Blanchard, 1904.) They can thus be the agents of inoculation for numerous diseases. Guiart (1905), who defends this view most strongly, believes that intestinal parasites play an important rôle in the etiology of diseases of the intestine and liver, such as insects play in the etiology of blood infections. He advances evidence to support the view from the records of both human and comparative parasitology. While recognizing fully that the infections are bacterial, he emphasizes the necessity of some inoculating agent as in a sense the most important element since pathogenic bacteria are generally present in the alimentary canal. No one can doubt, he maintains, that Eberth's bacillus is the agent of typhoid fever, but there is reason for regarding it as innocuous if the intestine is undamaged. In a population drinking contaminated water only a few persons in reality are infected. Any intestinal parasite capable of inflicting a wound may infect the host if the bacillus is present. The infecting agent may be an Ascarid, a hook worm, a fly larva; most commonly Guiart believes it to be the whip worm (*Trichuris*) which bores into the folds of the intestinal mucosa with its attenuated anterior end. This parasite Guiart (1901) calls the lancet of inoculation, and demonstrated its presence in eleven out of twelve typhoid cases in one group. It is interesting to note that in 1762 this species was looked upon as the cause of typhoid and its abundant presence was noted in many epidemics by early investi-

*Galli-Valerio (1903) has subjected a recent fatal case of appendicitis to most careful examination and finds in the contents of the perforated appendix numbers of *Oxyuris vermicularis* and eggs of *Trichuris*, while sections demonstrated numerous perforations of the mucosa made apparently by the parasites and in one case the worm still within the tissue. Neither the presence of the parasites nor the evidences of their work could have been determined without a microscopic examination, and in view of the usual lack of such examination this is sufficient answer to the objections cited above to the probable rôle of parasites in the etiology of this disease.

gators. After having gone to the opposite extreme, scientific opinion now shows a tendency to return to its earlier position and to regard the parasite an active factor in the introduction of the disease.

This unfortunate function as introducers of bacteria is, however, not confined to intestinal parasites. The chigo, or "jigger" a sand flea of some tropical regions, which burrows into the feet of natives, renders its host thereby exceedingly liable to infection, which in its secondary effects in the tropical clime, makes of a trivial injury one of serious consequence. The Guinea worm which burrows through connective tissue approaching the surface at the time when it desires to deposit its embryos and producing there small ulcers or openings to the exterior, menaces the well-being of its host, not by virtue of its own activity, but through the chance for infection to which it has subjected the host.

Parasites in many cases produce morphological or structural changes in their hosts, which may be classed in general as progressive histological changes in that they lead to the accumulation of material through the multiplying of the host cells.

Billroth indicated the extremely important fact that the multiplication of epithelial cells is caused by infection with micro-organisms, and it has been shown that protozoa as well as bacteria may cause infected cells to multiply. (Doflein, 1901.) Thelohan has shown that myxobolid infection produces a proliferation of muscle cells. Hofer and Doflein ascertained that in kidney infection by myxobolids increased growth in the skin resulted. It is also a distance effect, if not so great, when according to Leuckart the epithelial cells in coccidial nodules of the rabbit liver increase strongly in numbers. Among the epizoa there are many which produce such growths in the epithelium. The various species of itch mites excite a proliferation of the cells until there are formed crusts or thickened masses of considerable extent in which the galleries of the mites are constructed. These proliferations are said to be due merely to the mechanical stimulus exerted by the mites, and the crusts are formed by the addition of serous exudates. Such formations are thoroughly characteristic of the work of

these parasites. Less well known are other cases of the same type such as that of gall-producing copepods which infest actinia.

But such stimulation is not always purely indefinite. Parasites often produce unusual forms in the region of the host in which they reside; thus, Woodworth (1897) examining a skull of the common skunk, found that prominent swellings in the frontal bones near the sagittal plane were due to a nematode. The bone was extremely thin and in the subjacent frontal sinus lay a nest of fifteen to twenty of these parasites. The belief was expressed that the prevalent frontal enlargements of other American Mustelidæ are probably due to the same parasite.

Perhaps the most common form of morphological change on the part of the host is the production of a cyst about the parasite. It is composed in most instances, in part at least, by the host animal, and consists in its simplest form of an enveloping mass of connective tissue. This reaction against the invasion of the parasite is found in almost all groups.

The formation of pearls appears to be due regularly, if not exclusively, to the intrusion of parasitic larvæ. The host responds to the mechanical or chemical stimulus of the in-wandering larva by producing an epithelial sac which surrounds the parasite. Such a cyst formation by the host very generally follows when a parasite settles down to enter upon a resting stage in the body of the host. But here the character of the cyst wall leads normally to the formation of a deposit of lime of the same sort as the inner lining of the mollusk shell, and the larval parasite becomes the nucleus of a pearl. This stimulus to pearl formation is not given by any particular species of parasite but is traceable even to members of different classes of animals. Thus in European mussels (Dubois, 1901; Perrier, 1903) pearls are formed about the cercariæ of Trematodes.*

But in the Ceylon pearl oyster, which is more nearly related

*In one case carefully elucidated by Jameson (1902) the adult fluke inhabits the eider duck and the scoter, its sporocyst occurs in the cockle, while the tailless cercaria is found in the mussel and forms the nucleus of the small, lusterless pearls of that species. Another trematode is the cause of pearl formation in the fresh-water anodons.

to the mussels than to the oyster, the formation of pearls is due to certain cestode larvæ which undergo a portion of their development in the tissue of the liver, gills and mantle of the pearl oyster. Of these larvæ, such as for some yet unexplained reason do not succeed in carrying out their life cycle, become immured in the center of a pearl. Shipley and Hornell (1904), who have investigated with success these phenomena, say: "economically these unpleasant little creatures are of supreme importance to the Ceylon pearl fishery, as their presence in the oyster causes the formation of the finest quality of pearl and those of the highest luster." Another economic factor may be merely noted in passing. In 1859 Kelaart called attention distinctly to the possibility of infecting other beds with the larvæ of the pearl-producing parasites in order to increase the quantity of pearls. Beds of Ceylon pearls might thus be grown in other parts of the world. (Giard, 1903.) Kelaart says that the nucleus of an American pearl, drawn by Möbius, is of nearly the same form as that found in the pearl oyster of Ceylon.

It is interesting to note in comparison the record of Johnstone (1905: 116) that in the gurnard small pearl-like bodies are found adhering to the peritoneal investment of the intestine. The concetion is made up of a great number of concentric lamellæ which seem to consist of wavy bundles of connective tissue. These structures are probably derived from *Tetrarhynchus* cysts from which the larvæ had escaped and which had then undergone calcareous degeneration.

The amount of growth may be much greater than thus far indicated, and a condition among animals closely analogous to the formation of galls on plants has been observed by Nutting (1905). In certain Alcyonaria a tunnel formed of excessively enlarged spicules is found along one side of the stem or branch. The abnormal structure is due to an annelid. Greatly enlarged polyps in another genus owe their origin to the presence of crustacea or some other form of parasite.

Continued efforts have been made to demonstrate that the extensive pathological growths found in animals are due to the stimuli exerted by minute parasitic forms. It has been shown that in plants such abnormal growths are due to the

encroachments of parasites; but the effort to identify animal organisms as the cause of cancerous and other abnormal growths has in the opinion of most investigators failed to establish a case.

When we seek to ascertain the causes of the morphological changes which result from the influence of the parasite on its host it is difficult in the present state of knowledge to find any very definite explanation. Localized growth is ordinarily a factor of differentiation, but here it has no reference whatever to that process. Davenport in his admirable treatise on experimental morphology (1899) has given a very clear discussion of the factors in the effect of chemical and physical agents upon growth, and has brought together the evidence which shows the acceleration of growth by contact, by cutting, and by chemical stimulus. Now an examination of the cases in which growth is induced by parasites leads to the conviction that neither contact nor cutting can be a stimulating factor, since there are too many cases of parasitism in which no growth is produced, while in the exceptional case the presence of the parasite stimulates considerable growth activity. To be sure it has already been suggested that the formation of a cyst about a resting parasite is a normal activity of the host and occurs very generally if not universally. This may be the result of a contact stimulus; it may also be explained on the same basis as the other cases, viz., as a result of chemical stimulus. Under the discussion of the acceleration of growth by chemical stimulus, Davenport (1899: 332) says: "It is clear from this table that the addition of even small quantities of innutritious and poisonous substances may so affect the hylogenic processes as to cause twice or even far more than twice the normal formation of dry substance in a given time, and that this excessive growth increases with the concentration of the poisonous substances up to a certain optimum beyond which growth declines again to below the normal."

In suggesting that the stimulation of growth by parasites is traceable to a chemical stimulus, and that the stimulating substance is a poison, I am advancing a hypothesis which, even though it is a purely tentative one, may well engage our con-

sideration for a moment. Each parasite in the course of its activities produces a certain amount of waste material. It may safely be affirmed that this substance, which in the case of a resting parasite must be discharged directly into the tissue of its host, is to that tissue poisonous. If such material is given off in small amount it will evidently act as a stimulant upon the surrounding cells and be the factor in bringing together the leucocytes which accumulate about the invading organism. An inert body of the same size, if introduced into the same position, would not induce the formation of a cyst or certainly the tissue proliferations which accompany in some cases the attacks of parasites. It may even be doubted whether under the conditions for pearl formation, grains of sand, as formerly believed, will give the proper stimulus for the formation of the pearl. The important factor then must be one which is associated with the organism, not as an object occupying space, but as a living thing, and the most evident characteristic of this is the giving off of waste matter. This leads naturally to the next subdivision of the subject.

As physiological effects may be grouped together those influences of the parasite on the host which express themselves in the limitation or modification of the normal physiological processes of the latter. In some cases it is often true here that the primary effect is hidden and that the secondary result alone can be seen. It is sometimes possible to determine the primary result by study of the secondary, and to see the way in which it has been brought about. In other cases we merely know the secondary effects without being able to disentangle from the complicated series of phenomena the primary cause. Furthermore those interferences with normal function which are grouped under this heading are not such as might be traced to the action of the parasite as a foreign body, but such as are related to its own activity as a living organism. It will be seen that the distinction here is not perfectly clear, and perhaps somewhat artificial, for the mechanical disturbances of parasitism interfere with the normal activities of the host in the same way that other foreign bodies may modify or limit the working of the same organism. However, it is my intention

under this heading to consider the results which come from the contact of life with life, the interaction of function with function.

Perhaps the most evident factor and the most frequently mentioned, certainly the first to be noted in this connection, is the absorption of nutriment. The parasite demands a certain amount of food matter to carry on its own vital processes. This food matter is furnished so far as endoparasites are concerned at least, in a partially or fully digested condition, by the host animal. Many observers have maintained that the actual loss to the host in this way is so slight as to be negligible.

Leuckart (1879: 161) says that a *Dibothriocephalus latus* 7 meters in length weighs 27.5 grams, and gives off in a year a total of 15 to 20 meters of proglottids of a weight of approximately 140 grams, and that *Tænia saginata* produces daily on the average 11 proglottids, an amount equal to about 550 grams. These figures have been taken by some to indicate the actual loss of food material on the part of the host; this would be evidently insignificant in comparison with the amount consumed by a man within the year. It has even been suggested that the increased appetite induced by the presence of the parasite more than compensates for this slight loss. It would appear, however, that such a method of statement is exceedingly inadequate. It is very difficult to estimate the amount of food consumed by an animal in proportion to its weight, but it is certainly grossly insufficient to indicate this in any way as commensurate with the amount of growth which the animal achieves within a given period.

There is also another factor which must be taken into account, viz., that the parasite consists almost exclusively of actively functioning organs, and that there is a minimum of such inert parts as skeletal structures which add greatly to the weight of an animal, but do not involve the consumption of food material for their maintenance. It has been shown recently (Weinland, 1901) that parasites contain a large amount of glycogen; in analyses from one-fourth to one-third of the dry weight consists of this material. The highest value previously known was 14 per cent. in *Cardium* (a mollusk) and mammals apart from the liver have only about 3 per cent. Later the same author

(Weinland, 1901a) demonstrated that the vital processes of *Ascaris* proceed without oxygen and involve a fermentation process, resembling that of bacteria and yeast in producing butyric acid and alcohol. The possibility of such a wasteful process, measured in calories actually used, is found in the especially favorable conditions of existence of the parasite which afford it carbohydrates in superabundance and both protection and warmth from the host. But naturally the waste of the process means draft on the host.

Furthermore, the presence of the glycogen, which is unquestionably reserve material, indicates unmistakably that metabolic processes are exceedingly active in the organism. Another indication of the same thing is to be found in the reproductive activity. The tapeworm is producing and maturing an enormous number of eggs, each of which is supplied with a considerable yolk dowry. It is safe to affirm that during reproductive periods the draft of any animal upon its food supply is at a maximum. All of these three items, then, the rapid growth of the individual, the production of an unlimited supply of reserve material, and the extreme reproductive activity, point to a heavy draft upon the host. I have been unable to find any calculations which might be applied to such organisms as parasites with any likelihood that they would yield even approximate estimates of the material actually consumed. It would seem clear that previous calculations are incomplete and that the draft on the host is far greater than has been imagined heretofore.

An important effect on the host is traceable to the increase in the size of the parasite. This normal accompaniment of growth is most significant when the parasite occupies a limited space or when the increase in size is marked. The brain cysticercus, ordinarily found in a ventricle, grows until the cavity is occupied and then pressure upon the nervous tissue brings a sudden end to the life of the host. A liver hydatid may continue to grow almost without limit and only when important structures become involved is the pressure of serious moment. Most bladder worms do not exceed insignificant limits in growth and consequently exert little or no influence

on the host. The echinococcus, through its indefinite growth, is sure to reach a size which will interfere with the activity of the host, and from its usual location in the liver is likely to include important vessels, or nerves, and lead to fatal interference with normal functions.

Another general influence which parasites are thought to exercise on the host is explained by the hypothesis of reflex nervous action. According to this view intestinal parasites affect the host by irritating the nerve terminations and provoking in reflex fashion the varied troubles of helminthiasis which the clinician recognizes. This is a rôle which has been regularly ascribed to them and yet, as Guiart (1905: 176) says, this view is in fact a pure hypothesis. It has been invoked as an easy way to explain the results of parasitism and though attractive by its very simplicity, no evidence has been elucidated in its support, while at the same time many grounds have been advanced for other views. Accordingly, it is my intention to pass this hypothesis with the mere mention.

It has been frequently noted that parasitic infestation tends to retard the development of the host organism. In fact it does not hinder the general growth of the host strikingly but arrests primarily its sexual development. This has been especially investigated by Alfred Giard (1896), who denominates the phenomenon parasitic castration and defines it as the sum total of modifications produced by a parasite on the reproductive apparatus of its host, or on the portions of the organism indirectly in relation with that apparatus. The phenomenon appears to be wide-spread, instances being found in all branches of the animal kingdom and as the result of the most varied sorts of parasites. The character of this influence becomes evident through a simple comparison.

When an organ acquires undue importance one of the first physiological results of its hypertrophy is the arrest of sexual reproduction. Similarly when a parasite develops in an organism it causes sterility in its host. Such parasitic castration may be direct or indirect. The first case is met when the parasite destroys directly by mechanical means, or for its nutrition, the genital glands of its host. Parasitic castration

is indirect when the producing parasite is not directly in relation with the genital glands, but in some other part of the body of the host. Parasitic castration may also be temporary and then disappear when the parasite is suppressed.

The modifications caused by parasitic castration affect the genital organs, the secondary sexual characters and the sexual instincts of the infested animals; it may be partial to any degree and may exert the same influences on the secondary sexual characters as age or as artificial castration. Each one of the sexes loses more or less its characteristic attributes and tends to acquire in the same degree those of the opposite sex. Thanks to the effective labors of Professor Giard this phase of the influence of parasites on the host is more carefully worked out in comparative fashion than any other in the entire category. However, it would be clearly impossible within the necessary limits of this address to present the mass of evidence which he has collected from all parts of the animal and plant kingdoms.

A change which is mechanical to a certain extent and yet which has results of far deeper character, is the destruction of tissues by such parasites as actually feed upon the cells of the host animal. This is evidently due to the functional activity of the parasite, and for that reason will lie outside of the limits of a purely mechanical process and may be considered here. Schaper (1889) has shown that the liver fluke (*Fasciola*) feeds upon the substance of the organ in which it lives. Now this destruction of liver tissue removes from functional activity a certain portion of a most important organ. In addition to that it is followed by a growth of connective tissue, so that there is a permanent loss in the functional activity of the organ. Many different kinds of alimentary parasites actually feed upon the wall of the canal, with the result that by the feeding and burrowing of the parasites through the mucosa this important structure is destroyed over considerable areas; the wall of the canal comes to be covered with ulcers and suffers at these points permanent functional injury. (Kurlow, 1902.) The serious secondary effects in such cases have already been noted and they are evidently not in any sense directly proportioned to the extent of the injury, but the primary effect upon the

functional process of the organ is directly related to the number of such injuries, or, in other words, to the number of parasites at work. Other parasites burrow into the intestinal wall and produce there nodules of various sorts. Nematodes particularly determine the formation of such nodules in various organs of the host.* These nodules may be of considerable size, but in any event they involve the destruction of some functional tissue and the consequent impairment of the functional activity of the organ.

Among the physiological activities of parasites none is more striking in its reaction upon the economy of the host than the power that has been acquired by some forms which live upon blood to secrete a substance that inhibits the coagulation of the blood. Leo Loeb and Smith (1904, 1906) have recently shown that the hook worm secretes in glands of the anterior body region a substance which is exceedingly effective in inhibiting the coagulation of blood. This is antagonistic to the normal reaction of the mucosa. Consequently the points at which these parasites have attached themselves to the membrane become seats of continued hemorrhage, and in case of a numerous infection by the species there are myriads of minute hemorrhages constantly discharging blood† into the cavity of

*Thus *Sclerostoma equinum* produces tumors on the intestinal lining of the horse; *Spiroptera megastoma* in the submucosa of the horse; *Spiroptera sanguinolenta* in various organs of dog, fox, etc.; *Œsophagostoma columbianum* in the intestine of sheep; *Strongylus Ostertagi* in the fourth stomach of cattle; *Gnathostoma siamense* in the subcutaneous tissue of man (Vaullegeard, 1901).

†As a matter of fact Looss (1905: 133) has demonstrated that blood is not the normal food of the hook worm, as these parasites feed on the mucous membrane of the host, and blood is sucked in only when the parasite accidentally pierces a vessel. Looss takes the position that a toxin is produced which acts hemolytically, pointing out the fact that in some fatal cases of severe anemia the number of parasites found in the intestine was too few to explain the severity of the illness. It does not seem to me to be necessary to infer the production of some unknown toxin, since the possession of a secretion inhibiting the coagulation of the blood would account for the persistence of the hemorrhages, and it is this factor of continuance which makes of them dangerous elements. It is well known that the leech also produces such a substance in its glands.

the canal. The powerful anemia which is associated with the parasitism of the hook worm receives in this way a ready explanation.

There are many cases in which production of diseased conditions in the host appears distinctly traceable to the presence of a parasite and removable by the removal of the parasite. These diseased conditions are general, not local. They are apparently due to some abnormal stimulation and have usually been explained on the basis of the influence of toxic materials which the parasite produces (Nuttall, 1899; but see discussion in Blanchard, 1905). That parasitic organisms, like all other animals, produce waste matter and give it off into the fluids by which they are surrounded is not open to question. If the view already advanced of the active metabolism carried out by the parasites, and if the extremely highly developed excretory system are correct indications, then the amount of such waste material eliminated would be proportionately large. It is also undoubtedly true that various investigators (Messineo, 1901; Calamida, 1901; Mingazzini, 1901) have been able chemically to isolate toxic principles from the bodies of various parasites, and that in a number of instances these substances have been tested in their effects on living organisms with the result of producing changes or invoking symptoms distinctly analogous to those which have been recorded as the consequences of infection by the specific parasite. It also appears that the evidence which has been collected heretofore seems to indicate a difference in the degree of the effect exercised by living and by dead helminthes, for the latter are much more dangerous than the former; and yet it should be remembered that our precise knowledge of these matters is exceedingly limited. The production of a substance by extraction from a parasite is not sufficient evidence that the animal actually eliminates this material. It may be that in the final step of elimination there are changes which radically alter the character of the substance, and that consequently there is under natural conditions no such material in position to act upon the host individual. It should also be remembered in this connection that the parasites are generally located in those organs into which waste is nor

mally eliminated and by which it is discharged from the body; and, furthermore, that the parasitic organism sets free but a small amount of such waste material at any one time. These conditions would appear to indicate a minimum effect upon the host, if, indeed, any such is exerted; and in some cases it is denied that any such toxic material exists. (Le Dantec, 1905.)

On the other side, there are also certain incontestable facts. Not only is the recovery of such toxic substances from parasitic organisms by chemical means undoubted, but also it is known that as a result of injury or surgical intervention when a hydatid cyst is ruptured and the liquid content is diffused through the body, there are absorbed from it toxic substances which provoke serious results. Normally, the bladder worm is surrounded by a cuticula which retards osmosis, so that only a negligible quantity of toxin can be dispersed while the rest is accumulated in the vesicle.

Another argument which has been advanced to question the actual relation of these toxic substances to the pathological conditions of the host is the great amount of variability in different cases, not only as between the effect of different parasites which would naturally be explained on the basis of different types of toxic substance, but also with regard to the effect of the same parasite in different cases. Now this may easily be due to individual susceptibility on the part of the host animal, but there is another feature which would go far towards explaining this variable effect and yet it has never been suggested in this connection. Under certain conditions an animal will absorb toxic substances from its own alimentary canal and induce diseased conditions within itself as a result of this perverted function. The application of the same principle to the case of parasites would account for the absorption of toxic materials by one host and their elimination in another case.

So far as the protozoa are concerned, the evidence is positive that in some cases toxic materials are the cause of the effect produced by the parasite. Thus the Hemosporidia of malaria undergo their development within the red blood corpuscles, and at the time of breaking up into spores the corpuscle is destroyed and the accumulated toxic material set free in the blood. Since

the phenomena is synchronous for a large number of the parasites the amount of toxic material set free at once is considerable and is followed immediately by a febrile reaction, the periodicity of which is related to the successive reproductive cycles of the parasite.

The case of the Trypanosomes which are the cause of sleeping sickness is less definitely demonstrated, but apparently of the same type. In this disease no pathogenic changes can be observed in the host save a slight inflammation of the vascular membranes surrounding the spinal cord and brain. The toxins which the organisms in the spinal fluid produce must be set free in this fluid and thus act directly upon the central nervous system with the lethal effect characteristic of the disease. There sult here is certainly not morphological and is satisfactorily explained on the basis of the production of a deleterious chemical stimulation.

But little is known regarding the chemical character of the substances under dispute. The indefinite idea that some toxic substance is produced has been replaced in one or two instances by a definite idea regarding the material and its manner of working. Such is the case in hook worm disease, already discussed, and it may be that more extended study will furnish clearer ideas with regard to other cases. Some observers have determined the substances obtained extractively as leucomaines, while in other cases they have been found to be more nearly like enzymes. (Rievel und Behrens, 1903.) Certain of them react upon the blood with marked hemolytic power, while others of the ferment character affect nerve centers. An alkaloid which arrests muscular action has also been isolated.

The most difficult case to explain on any other theory than that of the production of toxic principles is the progressive, pernicious anemia, present in some cases of bothriocephalid infection. (Fédorov, 1902.) In spite of numerous investigations the case still remains obscure, but apparently one must admit that at least in special instances this parasite does excrete a particularly active toxin having hemolytic properties. Undoubtedly, the production of toxins by bacteria leads us to expect similar substances in this case also, but the argument

from analogy is a dangerous one in scientific demonstrations. Perhaps the strongest argument in favor of the view that parasites produce toxic substances is to be drawn from the occurrence of eosinophilia, which will be considered next.

Among the white blood cells are such as from their affinity of their granular contents for certain stains are known as eosinophile cells. They constitute from 2 per cent. to 4 per cent. of the normal leucocyte count, and an absolute increase beyond the normal number of 250 per cubic millimeter is designated eosinophilia. The conditions which produce an eosinophilia vary so widely that the cells have been termed the most capricious element of the blood. To a certain extent this seems true of the many varied reports of parasitic invasions on record, as some observers in the case of almost every species record the absence of any eosinophilia. Yet evidence is growing that eosinophilia is a strikingly constant symptom of infections with animal parasites, and experiments on lower animals as well as the most careful and extended observations on man are nearly uniform in their testimony to the existence of abnormal numbers of eosinophile cells in the blood.*

Some authors indicate what may be the explanation of the negative results of other observers. Thus Calvert (1902) noted in cases of *Filaria Bancrofti* that the development of the eosinophilia manifested a cyclical course, following by a few hours the periodicity of the embryo round worms in the peripheral blood and gradually decreasing to normal as the disease progresses. The percentage of eosinophiles varied in one case from 3 per cent. to 15 per cent. during twenty-four hours. The observation has been confirmed exactly by Gulland, while other observers record similar or greater variations, though the minimum figures are higher. In fact, such fluctuations seem characteristic not only for this parasite, but also of most other species. In some cases the eosinophilia does not make

*Thus tapeworm infection, hydatid cysts, the Egyptian blood flukes, and many other parasites, are associated with an increase in eosinophile cells in the blood. In trichinosis (Rosenbarger, 1901) it is the rule and in hookworm disease the main feature of the blood is an eosinophilia both relative and absolute.

its appearance at the first of the infection and after a marked increase subsequently declines or even disappears as the disease becomes chronic. A reappearance of the eosinophilia and also irregular fluctuations in it during the course of the malady are also noted. Such variations have been recorded in infections with tape-worms, with hook-worms, with trichinæ and with various filariæ. To what extent predisposition and immunity influence the phenomenon can not be judged at the present time, owing to insufficient data and incomplete observations. [The literature has been most carefully collated with full references in a most valuable paper by Shipley and Fearnsides, 1906.]

Equally characteristic with these fluctuations one must regard also the excessive degree of eosinophilia in parasitic diseases. While under other conditions an eosinophilia of 7 per cent. to 10 per cent. is usual, with rare instances of 35 per cent. to 50 per cent., in infections with animal parasites 10 per cent. to 30 per cent. is the average and 70 per cent. to 80 per cent., or even 87 per cent., the extreme. The number of cases with such high percentages is large, even though the records in general are not numerous, indicating even more distinctly the usual character of the exceptional eosinophilia in such cases.

The intimate relation of the eosinophile cells to the parasite is strikingly indicated by two well-established facts. The first already referred to is the increase and decrease of these cells in the peripheral blood as the embryos of *Filaria Bancrofti* appear in the superficial capillaries and disappear from them. The second was established by Opie (1904) experimenting with trichina on guinea-pigs. The increase in eosinophile cells does not begin until the embryos start to migrate and reaches its maximum when the majority of the embryos are in transmission from the intestinal mucosa by way of the lymphatic vessels and the blood through the lungs to the muscular system. Sabrazes (*fide* Shipley and Fearnsides, 1906) also found a great accumulation of cosinophile cells in the vicinity of hydatid cysts. All these facts would seem to indicate not only a stimulus, probably chemical, inducing the multiplication of the cells, but also a positive chemotactic influence which led the

cells towards the source of the stimulus. Since the stimulus originates from the parasites the simplest explanation finds it in the normal emanations of the animal, which as waste matter may be classed under the general category of toxins.

Among the physiological effects of parasitism is listed prominently the production of a condition of deterioration in the blood known as anemia, involving changes in the red blood cells and in bone marrow. In certain cases it has been possible to indicate with some definiteness the cause, as in the hookworm anemia, already discussed. External parasitism of blood-sucking species, such as leeches or fish lice (argulids) (Léger, 1906) produces anemic conditions through direct appropriation of blood, and if the parasites become numerous, enough is withdrawn to cause the death of the host.

But after the elimination of these instances there remain others in which an explanation can not be given at the present time. The most striking example of such cases is that of the broad fish tapeworm (*Dibothriocephalus latus*) frequently associated with a severe form of pernicious anemia which, indeed, is given the name of a bothriocephalus anemia. Also *Oxyurias* (Thebault, 1902) and *Ascaris* have been found less frequently in connection with the same pathological condition, though the connection is not satisfactorily demonstrated. Now in all these instances the amount of departure from the normal may vary from a very slight anemia to the maximum degree, while in many cases there appears to be no such effect from the presence of the parasite. The condition is also distinguishable from pernicious anemia due to inherent causes in that it disappears promptly with the expulsion of the parasites. (Askanazy, 1895.) Experiments made with an extract of the *Dibothriocephalus* injected into various animals have been successful in some cases in producing an anemia, but in other cases have failed. The reason for this anemia is not loss of blood, and equally contrary to known facts are the various hypotheses, based on the length of stay in the intestine, the predisposition of the host, and the condition of the parasite. The view that it is due to a toxin seems at present least open to criticism.

The discussion which has been laid before you in this address involves many terms which are rarely used in zoological circles, and many animals which are perhaps equally unfamiliar. To the average zoologist parasitism is a *terra incognita*, if not a *terra evitata!* The biological problems it presents were among the very first to be indicated, but have not received their proportionate attention in the intervening years. Just now there seems to be awakened interest in the subject and the results of investigations in this field are most hopeful. The subject is one which really overlaps the boundaries of zoology and encroaches upon the field of physiology and of medicine also. Much fine work has been done on the medical side of the topic, but the best results there can not be reached without generous co-operation from this side also. It is eminently fitting in this place to recall the splendid researches on morbific Protozoa carried out by a zoologist on the faculty of Columbia University. There is urgent need for similar work on other groups that the medical investigator may be furnished with those morphological, physiological and biological data upon which the successful prosecution of his studies depends. The work of the zoologists, Howard and J. B. Smith, on mosquitoes made possible the scientific victories of American physicians over disease in Havana and New Orleans. The recognition of hook-worm disease as an important factor in American medicine came through the pioneer work of the zoologist, Stiles. The splendid investigation of Councilman and his confrères on smallpox was not complete without the work of a zoologist, Calkins. The triumphs of modern science are being won by co-operative efforts and these are nowhere more indispensable than in the study of animal life, so peculiarly and closely related is it to the progress of the human reace. At no point, however, is the contact more intimate than here where the zoologist is called to join with the investigator in medicine in achieving the amelioration of man's physical condition and the suppression of disease.

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A STUDY IN VARIATION, GEOGRAPHICAL DISTRIBUTION AND MUTATION IN SNAILS OF THE GENUS PARTULA FROM TAHITI. BY H. E. CRAMPTON, COLUMBIA UNIVERSITY.

ON A CASE OF REVERSION INDUCED BY CROSS-BREEDING AND ITS FIXATION. BY W. E. CASTLE, HARVARD UNIVERSITY.

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REVERSION. BY C. B. DAVENPORT, COLD SPRING HARBOR, LONG ISLAND.

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OBSERVATIONS ON THE HABITS OF SALT MARSH MOSQUITOES. BY JOHN B. SMITH, NEW BRUNSWICK, N. J.

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AN UNDESCRIBED SPECIES OF NOCTUID MOTH FROM NEW YORK CITY. BY HENRY BIRD, RYE NEW YORK. (Illustrated by box specimens showing larvæ and habits.)

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NEW EVIDENCE FROM PRIMITIVE SHARKS ON THE ORIGIN OF THE LIMBS OF VERTEBRATES. BY RAYMOND C. OSBURN, COLUMBIA UNIVERSITY.

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ON THE STRUCTURE, DEVELOPMENT AND RELATIONSHIP OF BLASTOIDOCRINUS (BILLINGS, 1859). BY GEORGE H. HUDSON, PLATTSBURG, CLINTON CO., N. Y.

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NOTES ON THE PERIODICAL LITERATURE OF THE SMALLER DOMESTICATED ANIMALS. BY C. B. DAVENPORT, COLD SPRING HARBOR, N. Y.

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ORIGIN OF THE SPERM-CENTER IN THE FERTILIZATION OF CEREBRATULUS LACTEUS. BY NAOHIDE YATSU, COLUMBIA UNIVERSITY.

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A GRAPHIC METHOD OF CORRELATING FISH ENVIRONMENT AND DISTRIBUTION. BY ALBERT H. WRIGHT, CORNELL UNIVERSITY.

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VENATION OF THE WINGS OF PALEOZOIC DRAGON-FLIES. BY E. H. SELLARDS, UNIVERSITY OF FLORIDA.

NOTE ON THE ORIGIN OF THE MESODERM OF THE POLYCLAD, PLANOCERA INQUILINA WH. BY FRANK M. SURFACE, UNIVERSITY OF PENNSYLVANIA.

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LAND PLANARIANS IN THE UNITED STATES. BY L. B. WALTON, KENYON COLLEGE.

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SOME LITTLE-KNOWN SHARK BRAINS, WITH SUGGESTIONS AS TO METHODS. BY BURT G. WILDER, CORNELL UNIVERSITY.

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THE PRIMARY SEPTA IN THE RUGOSE CORALS. BY CLARENCE E. GORDON, AMHERST, MASS.

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EARLY STAGES IN STREPTELASMA AND ALLIED GENERA. BY THOMAS C. BROWN, COLUMBIA UNIVERSITY.

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FISSION IN THE HYDROID CORYMORPHA. BY HARRY BEAL TORREY, UNIVERSITY OF CALIFORNIA.

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VARIATION DURING THE LIFE-CYCLE OF INFUSORIA IN ITS BEARINGS ON THE DETERMINATION OF SPECIES. BY LORANDE LOSS WOODRUFF, WILLIAMS COLLEGE.

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NOTES ON THE LIFE HISTORY OF THE NEMATODE HÆMONCHUS CONTORTUS. BY B. H. RANSOM, BUREAU OF ANIMAL INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE.

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ON THE PLACE OF ORIGIN AND METHOD OF DISTRIBUTION OF TASTE BUDS IN AMEIURUS MELAS. BY F. L. LANDACRE, OHIO STATE UNIVERSITY.

THE CENTRAL REFLEX CONNECTIONS OF CUTANEOUS TASTE BUDS IN THE CODFISH AND THE CATFISH. AN ILLUSTRATION OF FUNCTIONAL ADAPTATION IN THE NERVOUS SYSTEM. By C. JUDSON HERRICK, DENISON UNIVERSITY.

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THE ORDER OF APPEARANCE OF THE AMBULACRAL APPENDAGES IN HOLOTHURIA FLORIDANA POURTALÈS. By CHARLES L. EDWARDS.

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SOME FURTHER POINTS IN THE DEVELOPMENT OF OPHIOTHRIX FRAGILIS. By E. W. MACBRIDE, M.A., F.R.S., MCGILL UNIVERSITY.

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EXHIBITION OF EMBRYOS OF THE JAPANESE FRILLED SHARK, CHLAMYDOSELACHUS ANGUINEUS, WITH COMMENTS UPON ITS PLAN OF DEVELOPMENT. By BASHFORD DEAN, COLUMBIA UNIVERSITY.

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MERCATOR PROJECTIONS OF VERTEBRATE AND ARTHROPOD EMBRYOS. By WILLIAM PATTEN, DARTMOUTH COLLEGE.

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THE PRE-PLACENTAL DEVELOPMENT IN GEOMYS BURSARIUS. By THOMAS G. LEE, UNIVERSITY OF MINNESOTA.

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THE MATURATION OF THE MOUSE EGG. By W. R. COE AND W. B. KIRKHAM.

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THE "ACCESSORY CHROMOSOME" IN ANASA TRISTIS. By KATHARINE FOOT AND E. C. STROBELL, NEW YORK.

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SECONDARY CHROMOSOME-COUPLINGS IN HEMIPTERA AND THEIR POSSIBLE SIGNIFICANCE. By EDMUND B. WILSON, COLUMBIA UNIVERSITY.

MATURATION PROCESSES IN PARAMECIUM CAUDATUM. By GARY N. CALKINS COLUMBIA UNIVERSITY.

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ON THE FORMATION OF REGENERATIVE MASSES IN SPONGES ALLOWED TO DEGENERATE IN CONFINEMENT. By H. V. WILSON, UNIVERSITY OF NORTH CAROLINA.

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THE INFLUENCE OF A STRONG CENTRIFUGAL FORCE ON THE EGG OF ARBACIA. By T. H. MORGAN AND E. P. LYON.

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THE INFLUENCES OF EXTERNAL FACTORS, CHEMICAL AND PHYSICAL, ON THE DEVELOPMENT OF FUNDULUS HETEROCLITUS. By CHARLES R. STOCKARD, COLUMBIA UNIVERSITY.

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THE DEGREE OF CORRELATION OF CERTAIN INTERNAL CHARACTERS IN THE TOAD. By W. E. KELLICOTT, WOMAN'S COLLEGE, BALTIMORE.

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MORPHOGENETIC LOCALIZATION IN AGLAOPHENIA. By RAYMOND PEARL, UNIVERSITY OF PENNSYLVANIA.

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CORRELATION AS THE BASIS FOR SELECTION IN LEPIDOPTERA. By H. E. CRAMPTON, COLUMBIA UNIVERSITY.

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THE BLENDING AND OVERLAP OF INSTINCTS. By FRANCIS H. HERRICK, WESTERN RESERVE UNIVERSITY.

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NOTES ON THE BEHAVIOR OF SEA-ANEMONES. By CHAS. W. HARGITT.

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THE SIMULATION OF DEATH BY FISHES. By ULRIC DAHLGREN, PRINCETON UNIVERSITY.

SPAWNING BEHAVIOR AND SEXUAL DIMORPHISM IN FUNDULUS HETEROCLITUS AND ALLIED FISH. BY H. H. NEWMAN, UNIVERSITY OF MICHIGAN.

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SOME POINTS IN THE DEVELOPMENT OF THE FLORIDA ALLIGATOR. BY ALBERT M. REESE, SYRACUSE UNIVERSITY.

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EXTERNAL MORPHOLOGY OF THE HEAD OF LIMULUS. BY WILLIAM PATTEN, DARTMOUTH COLLEGE.

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THE FUNCTION OF THE GASTROLITH OF THE LOBSTER. BY L. W. WILLIAMS, HARVARD MEDICAL SCHOOL.

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THE ARTIFICIAL PRODUCTION OF A SINGLE MEDIAN EYE IN THE FISH EMBRYO BY MEANS OF SEA-WATER SOLUTIONS OF MAGNESIUM CHLORID. BY CHARLES R. STOCKARD, COLUMBIA UNIVERSITY.

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METHOD OF MAKING SERIES OF ANATOMICAL DRAWINGS. BY G. A. DREW, UNIVERSITY OF MAINE.

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THE INFLUENCE OF DIRECTION *vs.* INTENSITY OF LIGHT IN DETERMINING THE PHOTOTROPIC RESPONSES OF ORGANISMS. BY LEON J. COLE, KINGSTON, R. I.

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CHROMATIN CHANGES IN HYDROIDS. BY W. M. SMALLWOOD, SYRACUSE UNIVERSITY.

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THE SEXUAL PHASE OF THE LIFE CYCLE IN AMŒBA. BY M. M. METCALF, OBERLIN COLLEGE.

THE EXISTENCE OF AN ORGAN OF EQUILIBRATION IN CERTAIN OF THE LOWER CRUSTACEA. BY C. O. ESTERLY, HARVARD UNIVERSITY. (Introduced by E. L. MARK.)

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THE HABITS AND LIFE HISTORY OF CRYPTOBRANCHUS ALLEGHENIENSIS. BY BERTRAM G. SMITH. (Introduced by Dr. O. C. GLASER.)

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RELATIONS BETWEEN REGENERATION, THE DEGREE OF INJURY, AND MOULTING IN YOUNG LOBSTERS. BY V. E. EMMEL, BROWN UNIVERSITY.

SECTION G.

# BOTANY.

## PAPERS READ.

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ELEMENTARY SPECIES AND HYBRIDS OF BURSA. BY GEORGE H. SHULL, STATION FOR EXPERIMENTAL EVOLUTION, COLD SPRING HARBOR, NEW YORK. (To be published in *Science*.)

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MENDEL'S LAW AS A TRACER OF LOST PARENTS—I. THE AMERICAN CARNATION. BY J. B. NORTON, U. S. DEPARTMENT OF AGRICULTURE.

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PRELIMINARY NOTE ON POLLEN DEVELOPMENT IN ŒNOTHERA LATA DE VRIES AND ITS HYBRIDS. BY R. R. GATES, UNIVERSITY OF CHICAGO.

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ON THE BEHAVIOR OF THE SEEDLINGS OF CERTAIN HYBRIDS OF VIOLA. BY EZRA BRAINERD, MIDDLEBURY COLLEGE, VERMONT.

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ORIGINATION OF SPECIES BY HYBRIDS AMONG WILD PLANTS. BY D. T. MACDOUGAL, CARNEGIE INSTITUTION. (To be published in the *Botanical Gazette*.)

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AN INSTANCE OF NATURAL HYBRIDIZATION. BY W. W. ROWLEE, CORNELL UNIVERSITY.

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A NATURAL SYSTEM OF THE DISCOMYCETES. BY F. E. CLEMENTS, UNIVERSITY OF NEBRASKA.

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ACCELERATED BLOSSOMING DUE TO DEFOLIATION BY STORM. By ERNST A. BESSEY.

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AN OUTBREAK OF THE EUROPEAN CURRANT RUST, CRONARTIUM RIBICOLA DIETR. By F. C. STEWART, GENEVA, NEW YORK.

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THE ORIGIN OF THE HYMENIUM IN SOME GEOGLOSSACEÆ. By E. J. DURAND, CORNELL UNIVERSITY.

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NOTES ON THE EMBRYOLOGY OF RHIZOPHORA MANGLE. By MEL. T. COOK, SANTIAGO DE LAS VEGAS, CUBA.

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THE EMBRYOLOGY OF RHYTIDOPHYLLUM CRENULATUM AND R. TOMENTOSUM. By MEL. T. COOK.

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RADIOACTIVITY A FACTOR IN PLANT ENVIRONMENT. By C. STUART GAGER, NEW YORK BOTANICAL GARDEN.

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SOME EFFECTS OF RADIOACTIVITY ON PLANTS. By C. STUART GAGER, NEW YORK BOTANICAL GARDEN.

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THE PATHOLOGY OF THE RICE PLANT. By HAVEN METCALF, U. S. DEPARTMENT OF AGRICULTURE.

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THE RÔLE OF CERTAIN ELEMENTS IN THE PHYSIOLOGY OF THE PLANT CELL. By HOWARD S. REED.

SOME MUTUAL EFFECTS OF TREE-ROOTS AND GRASSES ON SOILS. By CHAS. A. JENSEN, BUREAU OF SOILS, U. S. DEPARTMENT OF AGRICULTURE.

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THE BOTANICAL HISTORY, CLASSIFICATION, AND SOME USES OF SORGHUM. By CARLETON R. BALL, U. S. DEPARTMENT OF AGRICULTURE.

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PERIODICITY OF THE SEXUAL CELLS OF DICTYOTA DICHOTOMA. By W. D. HOYT, JOHNS HOPKINS UNIVERSITY.

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EVIDENCES OF SEXUAL REPRODUCTION IN THE SLIME-MOLDS. By EDGAR W. OLIVE, UNIVERSITY OF WISCONSIN. (Read by C. A. King.)

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LOCALIZATION OF PLANTS IN THE FINGER LAKE REGION AND THE ADJACENT ONTARIO LOWLANDS OF CENTRAL NEW YORK. By W. W. ROWLEE, CORNELL UNIVERSITY.

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CLASSIFICATION OF THE PANICEÆ. By (Mrs.) AGNES CHASE, UNITED STATES DEPARTMENT OF AGRICULTURE. (Read by title.)

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THE SUB-AERIAL ABSORPTION OF WATER; A FUNCTION OF THE LIGULE AND STIPULACEOUS TISSUE OF THE GRASSES. By F. L. STEWART, MURRYSVILLE, PA.

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"G" TREES. By S. M. TRACY, BILOXI, MISS.

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PARASITISM OF BUCKLEYA DISTICHOPHYLLA (NUTT.) TORR. By SAMUEL M. BAIN, UNIVERSITY OF TENNESSEE.

THE PLANT DISEASE SURVEY OF THE UNITED STATES. By W. A. ORTON, BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE.

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FASCIATION IN THE ŒNOTHERAS. By ALICE ADELAIDE KNOX, CARNEGIE INSTITUTION.

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A RECORDING EVAPORIMETER. By BURTON EDWARD LIVINGSTON, DESERT BOTANICAL LABORATORY.

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A COMPOSITE LYCOPOD TYPE FROM THE DEVONIAN. DAVID WHITE, U. S. GEOLOGICAL SURVEY.

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HYBRIDIZATION A FACTOR IN MIGRATION AND COMPETITION. By E. N. TRANSEAU, ALMA COLLEGE, MICHIGAN.

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THE MORPHOLOGY OF LEMNA TRISULCA. By OTIS W. CALDWELL, STATE NORMAL SCHOOL, CHARLESTON, ILL.

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THE STRUCTURE AND WOUND-BEHAVIOR OF THE CEDAR OF LEBANON. By EDWARD C. JEFFREY, HARVARD UNIVERSITY.

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TYLOSES IN THE TRACHEIDS OF CONIFERS. By MINTIN A. CHRYSLER, HARVARD UNIVERSITY.

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THE HOMOLOGIES OF THE MEDULLA IN THE FILICALES. By J. HORACE FAULL, UNIVERSITY OF TORONTO.

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POLYSTELY IN THE ORCHIDACEÆ. By J. H. WHITE, UNIVERSITY OF TORONTO. (By invitation.)

THE ARAUCARIEÆ—A "PROTO-SIPHONOGAMIC" METHOD OF FERTILIZATION. BY ROBERT BOYD THOMSON, UNIVERSITY OF TORONTO.

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THE FLOWERING PERIOD OF A HYBRID OPUNTIA. BY F. E. LLOYD, DESERT BOTANICAL LABORATORY.

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A STUDY OF THE LEAF-TIP BLIGHT OF DRACÆNA FRAGRANS. BY JOHN L. SHELDON, WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION. (Read by request before the Botanical Society of America.)

SECTION H.

# Anthropology.

# ADDRESS

BY

GEORGE GRANT MacCURDY,

VICE-PRESIDENT AND CHAIRMAN OF SECTION H FOR 1906.

## *SOME PHASES OF PREHISTORIC ARCHÆOLOGY.*

The American field for anthropological research is so wide and so fertile that it not only monopolizes the attention of specialists at home, but also attracts to our shores numerous foreign investigators. For attestation of this fact, one has but to cite the fourteenth International Congress of Americanists held in the city of Quebec last September. The same Congress had convened in the New World twice before, once in New York City and once in the city of Mexico, the remaining sessions having been held in various European cities.

When foreign savants take such a deep interest in our own problems it is fitting that we should reciprocate by at least an occasional survey of the foreign field. In looking over the list of vice-presidential addresses read before this section, I find that two such surveys have already been made.* The address of Professor E. S. Morse, entitled: "Man in the Tertiaries," was a powerful argument in favor of the existence of man's ancestors in Tertiary times. Fifteen years later Dr. Thomas Wilson chose for his subject: "The Beginnings of Prehistoric Anthropology."† He not only had something to

*Vice-Presidential Address, Proc. A. A. A. S., 1884, XXXIII, 579.

†Vice-Presidential Address, Proc. A. A. A. S., 1899, XLVIII, 309.

say about Tertiary man, but also covered the paleolithic and neolithic periods. In the more than seven years that have elapsed since Dr. Wilson's address was read, much progress has been made in the prehistoric archæology of Europe. This is especially true concerning our knowledge of the *eolithic question* and of *paleolithic art* in so far as it has to do with engravings and frescoes on certain cavern walls. In fact, eoliths and paleolithic mural decorations were not even mentioned by Dr. Wilson. He did refer, however, to Harrison's discoveries of "paleoliths" on the chalk plateau of Kent, but confused these with the well-known river-drift implements.

## THE EOLITHIC PERIOD.

When Thomsen published his relative chronology for prehistoric times in 1836, the only stone age known was that which is now called the neolithic period. Boucher de Perthes's first discovery of paleoliths in the river-drift of the valley of the Somme came just two years later. These river-drift implements, however, were not accepted until after (Sir) Joseph Prestwich's visit to Abbeville in 1859.

Is there a stone industry antedating the paleolithic? The answer depends in a measure upon the definition of the term. The Chellean *coup de poing* is quite generally looked upon as representing the oldest paleolithic industry. As to its position in the geological scale opinions differ. Piette and de Mortillet placed it in the Lower Quaternary. According to the more recent classifications of Rutot and Boule, the Chellean belongs to the Middle Quaternary. If the latter view is correct, then a pre-Chellean industry need not necessarily be of Tertiary age. The presence of artifacts in the Lower Quaternary should not be surprising even to the most sceptical. This is particularly true in view of the fact that the well-known almond-shaped implement represents an advanced stage in the art of chipping flint. While Professor M. Boule does not doubt that industrial remains may exist in the Lower Quaternary and even in the Tertiary, he denies that they have as yet been discovered. In his own words as a paleontologist he has a

firm faith in the existence of Tertiary man, traces of whom he believes will some day be found. On the other hand, Dr. A. Rutot accepts as man's handiwork the rudely chipped specimens not only from the Lower Quaternary, but also from the Pliocene and Upper Miocene.

The first serious claim for the existence of a Tertiary industry was made by the Abbé Bourgeois in 1867. The subject at once attracted considerable attention; but after a lively discussion that lasted for five or six years it was relegated to the background. The specimens that Bourgeois found in the Upper Oligocene at Thenay are not at present accepted as artifacts.

Carlos Ribeiro's discovery of chipped flints in the Upper Miocene and Lower Pliocene at Otta and other localities near Lisbon was announced in 1871. An account of Delgado's researches at Otta was published in 1889. Professor Verworn,* who recently visited this locality, is of the opinion that the deposits there have been so disturbed as to make the age of the artifacts doubtful. They may be paleolithic and even neolithic.

The problem is simpler at the classic stations near Aurillac (Cantal). The best known of these are at Puy-Courny and Puy de Boudieu. Here the deposit in question is of Upper Miocene age, fossiliferous and undisturbed. It is covered by a bed of andesitic tufa that attains in places a thickness of from sixty to one hundred meters. There is no doubt as to the geological age of the chipped flints. As to the nature of the chipping, however, opinions differ.

When attention was called to the first specimens discovered by Rames in 1877, such well-known authorities as de Mortillet, Cartailhac, Chantre, de Quatrefages and Capellini declared that if these flints had been found in Quaternary deposits, no one would hesitate to regard them as artifacts. The Cantal industry has been carefully studied in more recent years by Capitan, Rutot, Courty, Klaatsch and Verworn, all of whom have decided in favor of its genuineness.

* Max Verworn. Archäolithische und paläolithische Reisestudien in Frankreich und Portugal. Zeit. für Ethnol., 1906, S. 611.

The revival of interest in a pre-paleolithic industry in England began when Mr. Benjamin Harrison of Ightham, Kent, who had been collecting paleoliths from the river-drift of the neighborhood for years, extended his field of search in 1885 to include the summit of that portion of the chalk plateau which lies between the valley of the Darent on the west, and that of the Medway on the east. Here at heights of from four hundred to seven hundred feet above the sea, he discovered flints supposed to have been chipped by the hand of man.

As Harrison's collection grew it was submitted to Sir Joseph Prestwich, whose country-seat was at Shoreham in the Darent valley near by. Thirty years earlier Prestwich had confirmed the accuracy of Boucher de Perthes's discoveries in the valley of the Somme. Who could be better fitted than he to answer the questions as to the age of the specimens and of the southern drift in which they occur, as well as to the character of the chippings? According to Prestwich, the rudely chipped flints are artifacts and are as old as the southern drift. They are both older than the northern drift or boulder clay, and hence pre-glacial. Rutot places them in the Middle Pliocene. The southern drift (with implements) was transported across the chalk escarpment and the chalk plain into the Thames valley along lines independent of the present drainage; the patches that are now left on the highest points (eight hundred and sixty-four feet at Titsey hill west of the Darent valley), marking what were then the valleys.

Mr. J. Allen Brown,* in discussing the specimens found on the North Downs by Harrison, was the first to propose the term "eolithic," now so much in evidence. Two years later, G. de Mortillet made use of the term in his *Classification palethnologique*,† applying it to the Tertiary only. Dr. Rutot‡ does not limit the eolithic period to the Tertiary. In his classification, as previously stated, the early phases of the

*Jour. Anthr. Inst., March 8, 1892, XXII, 93–94.

†Bull. Soc. d'anthr. de Paris, 1894, p. 616.

‡Bull. Soc. belge de géol., de paléon. et d'hydrol., Bruxelles, 1903, XVII, 425.

Quaternary are also eolithic, the well-known hache type (Chellean) not appearing until the second advance of the ice.

Eoliths are by no means confined to Kent. They have been found by Shrubsole in Berkshire; by Blackmore, Bullen and others near Salisbury, Wilts; at Dewlish in Dorset; also in Surrey, Hampshire, the southern part of Essex and Norfolk. Mr. Percival A. B. Martin has found eoliths at a number of places on the South Downs in the neighborhood of Eastbourne and Beachy Head.

Are eoliths artifacts? This is the fateful question. Their geological age is of no consequence if they are only natural forms and have never been used by man or his precursor. The first flakes to be utilized were in all probability natural forms. It is not likely that eolithic man knew how to obtain the raw material from the chalk. He depended on picking up from the drift flakes of approximately the shape and size needed. A sharp edge was utilized once, twice, or until it became dulled, and was then cast aside. If an angular piece did not admit of being comfortably grasped in the hand, the troublesome corners were removed. Such conclusions as these are forced upon one after careful examination of a series of the specimens in question. Would the same conclusions be so irresistible if these objects were merely Nature's playthings? Many may even be grouped according to more or less definite patterns. Two of these deserve special mention, viz., the small crescent-shaped scrapers comparable to the spoke-shave, and the double scrapers with an intervening point between the two scraping edges. Sometimes two margins are worked, but on opposite sides. That is to say, after chipping one of the margins, instead of rotating the specimen until the adjacent margin comes into play, it was reversed.

Belgian archæologists were among the first contributors to our knowledge of a pre-Chellean industry. The discoveries by Neyrinckx in the railway cut at Mesvin between Mons and Harmignies, date from 1868. M. Émile Delvaux later took up the work at Mesvin, where he succeeded in determining the presence of a rude industry antedating the paleolithic, to which he gave the name Mesvinian. During the past twenty

years, Belgium's most indefatigable worker in the prehistoric field has been Dr. Rutot, his studies being confined chiefly to the Quaternary deposits.

The river valleys of Belgium are often marked by three terraces: The upper terrace, of Pliocene age, about ninety meters above the present water-level; the middle terrace at an elevation of from twenty-five to sixty-five meters, and the lower terrace a little above high-water-level, both of Quaternary age. The Quaternary may be divided into five series of deposits. Beginning with the oldest, these are: (1) Mosean; (2) Campinian; (3) Hesbayan; (4) Brabantian; (5) Flandrian. These deposits have been carefully examined by Rutot in quest of industrial remains.

With the exception of the Brabantian, which is above the eolithic zone, all five divisions of the Quaternary are represented in section in the Exploitation Hélin at Spiennes, near Mons, phosphate works now owned by the Société de Saint-Gobain. All of the Quaternary eolithic epochs are likewise represented here with the exception of the oldest, the Reutelian. Rutot found that the three separated industry-bearing Campinian layers each furnished one of the several elements composing the industry previously found elsewhere in disturbed Campinian deposits. In the lowest of the three, there were not only eoliths of Mesvinian age, but also rude implements roughly amygdaloid in shape, selected flint nodules only slightly chipped to a semblance of the hache type, or poniard. All the requirements of a transition industry between the Mesvinian (eolithic) and the Chellean (paleolithic) are therefore satisfied. The middle layer furnished examples of the classic *coup de poing;* and in the uppermost layer there were specimens of the hache type, carefully chipped on both sides until the margins presented almost a straight line as opposed the zigzag margin of the Chellean implement—in other words the so-called Acheulian industry of M. d'Ault du Mesnil. Rutot has proposed the name Strépyan for the industry of transition from the eolithic to the paleolithic, because of the character and abundance of the specimens found at Strépy on the right bank of the Haine between Estinnes and Cronfestu.

Following Rutot's lead, many German investigators have taken up the search for a pre-paleolithic industry in northern Germany, particularly in the valleys of the Elbe and Spree and on the Island of Rügen. The chief contributors have been Professors H. Klaatsch, Eugene Bracht and Max Verworn, and Drs. Hans Hahne, G. Schweinfurth,* Eduard Krause, *et al.*

For some years past, the spread of the eolithic propaganda has been so rapid as to cause dismay in the camp of its opponents. I spent the summer of 1903 in England and Belgium for the express purpose of studying the question at closer range. That summer's work formed the basis for a preliminary report† read at the St. Louis Meeting of the American Association at the close of the same year, as well as for a more extended paper‡ published in 1905. Before the latter was out of press, there appeared an article by Professor Boule,§ intended as a severe blow to the genuineness of eoliths. He had been trying for twenty years to stem the rising tide in favor of a pre-paleolithic industry and was beginning to think of instituting experiments in the hope of throwing light on the origin of eoliths, when M. A. Laville, preparator at the *École des Mines*, Paris, found an experiment station already in working order and turning out "eoliths" daily by the hundreds. It was a cement factory on the left bank of the Seine, two kilometers southeast of Mantes, near Paris.

In extracting the chalk from the quarry most of the flint nodules are cast aside. Some, however, pass unnoticed by the workmen and are carried with the chalk to the factory. This, together with a certain amount of clay is emptied into circular basins (délayeurs) or diluters. These vats have a diameter of about five meters, and a depth of 1.4 meters. The water is supplied by means of conduits and finally escapes through lateral sieves carrying with it a mixture of chalk and clay both highly pulverized.

*Schweinfurth's studies have been confined chiefly to Egypt.

†Science, 1904, p. 449.

‡The Eolithic Problem—Evidences of a Rude Industry Antedating the Paleolithic: Amer. Anthropol., N. S., VII, 425–479.

§L'Origine des éolithes. L'Anthropologie, t. XVI

Each circular vat is provided with a horizontal wheel, the spokes of which are armed with cast-iron teeth that reach to within two-tenths meters of the bottom, the wheel itself being just above the surface of the mixture. This wheel, with a diameter of five meters, and making sixteen revolutions a minute, attains a velocity at the circumference of about four meters a second.

In this whirlpool of moving water, chalk, clay, and iron teeth, are also the flint nodules that escaped the notice of the quarrymen. These nodules therefore receive thousands of knocks, some mutual, some from the iron teeth, until at the end of a period of twenty-nine hours the machinery is stopped and they are removed. They are then washed and piled up to await their ultimate use as a by-product. It was in one of these piles that M. Laville's* discovery was made. Later he visited the place in company with Messieurs Boule, E. Cartailhac and H. Obermaier.

According to Boule, the flints that have passed through the machine have all the characters of the ancient river gravels. Most of them have become rounded pebbles. Many, however, are chipped in a manner to resemble a true artifact. He and his companions were able in a few minutes to make a "superb collection including the most characteristic forms of eoliths, hammer-stones, scrapers, spoke-shaves," etc. His article is illustrated by half-tone figures, which, however, are of very little use to the reader. Photographs of eoliths are practically useless; faithfully executed line drawings are little better; a view of the objects themselves is absolutely necessary before passing judgment on their origin.

Professor Boule does not pretend that all eoliths have a natural origin more or less analogous to those made by machinery. He does claim "that it is often impossible to distinguish between intentional rudimentary chipping and that due to natural causes." In his opinion the artificial dynamics of the cement factory are comparable in every respect to the dynamic action of a natural torrent.

Nothing is really gained even by proving the impossibility

*Feuille des jeunes naturalistes, 1905, p. 119.

of distinguishing between man's work and chipping due to natural causes. If the argument is worth anything it will admit of a still wider application because of the fact that it is admittedly impossible to distinguish between certain true eoliths and some artifacts of the paleolithic and neolithic periods. Things that are equal to the same thing, are equal to each other. By substituting, therefore, one arrives at the identity between stream-made and machine-made eoliths on the one hand, and recognized artifacts on the other. This does not prove the non-existence of true eoliths any more than it does that of the paleolithic or neolithic artifacts.

If streams at flood ever produced eoliths it is more than probable that they may still be doing so. While keeping one eye on the chalk-mill at Mantes, might it not be well to keep the other on the Seine that flows near by. A few Seine-made eoliths would certainly be more convincing than those turned out at the factory.

It has not been my good fortune to see one of these cement factories at work. It is evident from the available literature on the subject that considerable prejudice has entered into the controversy. Messieurs Laville, Boule *et al.*, were evidently seeking for what they claim to have found at Mantes. On the other hand it was extremely unfortunate that certain believers in an eolithic industry were refused admittance into the Mantes establishment. A selected series, however, from Mantes, which was sent in 1905 to the Salzburg Meeting of the German Anthropological Association by Dr. Obermaier, was later placed at the disposal of Professor Verworn and Dr. Hahne. Verworn compared them with his collection of eoliths from Cantal, while Hahne compared the Mantes specimens with a similar series from a chalk-mill on the Island of Rügen, and the eoliths from Belgium sent to him by Rutot.

Dr. Rutot has sought to match his superb collection of eoliths in the Royal Museum of Natural History, Brussels, with specimens from the chalk-mills of Belgium, but in vain. Professor Verworn and Dr. Hahne have been no more successful in their comparative studies. All three agree in their general conclusions as to the radical differences between the true

and the false eoliths; also that the action of the mill is hardly comparable with that of the natural streams of the regions in question except in one particular, viz., both tend in time to make pebbles of the flints that are offered to them.

According to Professor Verworn,* a fundamental difference exists between the eoliths he found at Puy de Boudieu and the pseudo-eoliths from Mantes. The corners and edges of the latter are worn, while those of the Cantal eoliths are not. It has been suggested that the chipping on the specimens from Puy de Boudieu may be due to pressure of the overlying beds. Such a result might be possible where unstable beds contained a sufficient quantity of flint nodules and chips pressing against each other. At Puy de Boudieu, however, the chipped flints are not resting against each other. They are separated by masses of tufa, loam and sand.

After a careful comparison of machine-made eoliths from both Mantes and Sassnitz with the Mafflean and Mesvinian industry from Belgium, Dr. Hahne's† conclusions are as follows: (1) The chalk-mill flints are all scratched and otherwise marked by the iron teeth of the mill. (2) The sides of all the larger pieces are bedecked with scars from blows that were not properly placed to remove a flake. (3) Almost every piece shows more or less of the original chalky crust of the nodule. (4) Anything like a systematic chipping of an edge or margin is never found except for very short stretches where one would expect it to be carried along the entire margin. This is quite different from the long retouched margins of most eoliths. (5) The same edge is often rechipped first on one side and then on the other absolutely without meaning or purpose. The "reverse working" of true eoliths is quite another thing. (6) In the mill product coarse chipping alternates with fine retouches along the same margin, while on the eolith there is a regularity and orderly sequence of chipping. (7) The repeated rechipping of the same edge, while others are left untouched, does not occur in machine-made eoliths. (8) The chief difference

*Op. cit., p. 620.

†Über die Beziehungen der Kreidemühlen zur Eolithenfrage. Zeit. für Ethnol., 1905, S. 1024.

is between the haphazard and meaningless on the one hand, and the purposeful on the other.

The most prominent and easily breakable parts suffer most in passing through the mill. They are often retained intact, or only slightly altered, on the eolith to serve as a hand-hold, and there is a logical relationship between the worked and unworked portions.

The eolithic problem in northern Germany is even more difficult of solution than that of chalk-mill "eoliths." Dr. Klaatsch, who had previously made a study of eoliths in France and Belgium, was among the first to find so-called eoliths in fluvio-glacial deposits in the valley of the Spree. His discoveries were supplemented by Dr. Hahne's in the valley of the Elbe. At this latitude, the deposits of the first glacial and first interglacial period, containing what appears to be an eolithic as well as a transition (Strépyan) industry, were very much disturbed by the second advance of the ice.

The result is that the pieces in question are so badly damaged as to obscure the evidence bearing on their genuineness. The German geologists and anthropologists are divided as to the proper interpretation to place upon these specimens. After going over the material with Dr. Hahne, Rutot is of the opinion, that after all doubtful pieces are rejected there will remain enough to establish the existence of an eolithic industry in those regions.

Another subject studied in common by Rutot* and Hahne is that of shore-made eoliths, the locality being a favored stretch of coast on the Island of Rügen in the Baltic Sea. The chalk cliff is surmounted by a moraine with large erratic blocks. When the seas run high, the large blocks and glacial till are thrown forward over the cliff. Masses of the fissured chalk are also loosened and fall to the foot of the cliff. With recurring high seas, broken nodules of flint come in contact with the erratic blocks and the production of pseudo-eoliths begins. If left, however, to their own fate they are finally reduced to sand. When rescued at the proper time, they resemble more

*Éolithes et pseudo-éolithes. Mém de la Soc. d'anthrop. de Bruxelles, 1906, t. XXV.

or less the true eolith. They certainly form a more convincing argument in favor of the natural origin of all eoliths than do those from the chalk-mills. But they resemble the latter more than they do the genuine eolith, which, according to Rutot and Hahne is still unaccounted for unless it represents the handiwork of man or his precursor.

The differences are not great enough to be detected by the untrained eye. They may be compared to the differences between hand-made and machine-made music. The untrained ear might not detect them without seeing the operator at work, but no such substitution could deceive an expert. It would be rather wide of the mark to conclude that, because pianos may be played by the pianola, they were never played by hand; or if ever played by hand the result must necessarily be identical with that produced by the pianola.

The wide differences of opinion in the opposing camps can hardly be due to prejudice alone. Faulty or insufficient observation and incorrect interpretation doubtless play their part. Luckily there is no disposition to drop the matter until the truth appears. At the International Congress of Anthropology and Prehistoric Archæology held at Monaco, April 15 to 22, 1906, the chief subject of the second session was the pedigree of the eolith. According to *Nature*,* "a series of mill-modeled flint nodules was exhibited, among which there was certainly a number closely resembling many Prestwichian types, but conspicuous by their absence were the decidedly purposeful and rationally usable Kentian forms." On the other hand, Professor E. Ray Lankester "submitted that he had recently placed on exhibition in the British Museum, a considerable series† of specimens selected from Prestwich's collection, all borer-like in form, too identical in shape and so rationally of obvious utility for any possibility of their being the result of fortuitous natural collisions."

As a further indication of the importance attaching to a correct solution of the problem and indirectly in recognition of the value of Rutot's contribution toward such a solution,

*June 28, 1906, p. 211.

†Amer. Anthropol. (N. S.), 1905, VII, 432, 433.

the Meeting of the German Anthropological Association for 1907 will be held in Cologne* in order that the members may visit the eolithic stations of Belgium and see the collections of the Brussels Museum.

## THE ART OF THE CAVE-DWELLER.

Passing now from Tertiary and Lower Quaternary eoliths and leaving out of account for the time being the important industry of the Chellean and Mousterian epochs, we come upon a most interesting chapter in the history of paleolithic man—a chapter to which many attractive pages have been added during the past ten years. It concerns the art of the Cave-Dweller.

One of the earliest enlightened searchers for prehistoric man in caverns was the Rev. J. MacEnery, a Roman Catholic priest, stationed at Torquay on the southern coast of England. As early as 1825 he found, in Kent's Cavern, flint implements definitely associated with the remains of the mammoth, rhinoceros and other extinct animals.

Then came, in 1833, the discoveries of Schmerling in the caverns about Liége, Belgium; but these also did not receive the attention they deserved, owing to the then all-powerful influence of Cuvier.

Following the appearance of Darwin's Origin of Species, and the acceptance of the river-drift implements as artifacts, both of which events occurred in 1859, cavern explorations received a new impetus. In Europe alone hundreds of paleolithic caverns have already been explored. About one-third of these are situated in France. Some of the well-known localities outside of France are the regions about Namur and Liége, Belgium; Liguria in Italy; Moravia in Austria; and Schaffhausen in Switzerland.

To the student of the cave-dweller period, southern France is perhaps the most fruitful field in all Europe. Of this area Les Eyzies and its environs in the valley of the Vézère, depart

*It is proposed to make the Cologne Congress International. American Anthropologists have been invited to take part. Place of meeting has been changed to Strassburg. The date is August 4–8.

ment of Dordogne, is one of the chief centers. It was in 1862 that M. J. Charnet found in a shallow cave at Les Eyzies the first flint implements and breccia, with bones of the reindeer and other animals. He communicated the facts to Professor Eduard Lartet of Paris and Mr. Henry Christy of London, who visited the place in August, 1863, making explorations simultaneously at Les Eyzies, Gorge d'Enfer and Laugerie-Haute.

This led, in 1865, to the plans for a great publication to be called "Reliquiæ Aquitanicæ." In importance, as well as in authorship, this is an international volume. The specimens described belong to the Christy Collection of the British Museum and to the Museum of National Antiquities at Saint-Germain. The Lartet and Christy explorations were practically confined to the rock-shelters and shallow caves. If these men had lived longer, they might have discovered the extensive subterranean caverns of the neighborhood, the walls of which are decorated with a remarkable series of frescoes and engravings.

The valley of the Vézère has been an attractive field for archæological excursions ever since the appearance of Lartet and Christy's classic work; and has come even more into favor since 1895, when the first discovery was made of engravings and frescoes on the walls of one of the caverns. Several other caverns have been explored during the past six years with similar results. In company with a small party of Frenchmen from Paris, members of the *Société des Excursions Scientifiques*, I visited the region during the summer of 1903.

Vézère collections have found their way practically into all the important museums of the world, but the British Museum (Bloomsbury); the Natural History Museum, Paris, and the Museum of National Antiquities at Saint-Germain-en-Laye contain the major part. These should all be visited before, as well as after, a trip to the Dordogne. The train can be taken direct from Paris (*Gare d'Orléans*) to Périgueux, the capital of the department of Dordogne, the site of ancient Vesuna of the Petrocorii and later a flourishing Roman town. Here one may stop with profit to see the ruins of a Roman amphitheatre and tower, also the *Musée de Périgord*, rich in prehistoric relics of Dordogne, including the Vézère region.

From Périgueux it is less than two hours by train to Les Eyzies, the heart of the cave-dweller country where one stops at the *Auberge Berthoumeyrou*, well and favorably known to a long line of pilgrims to this enchanted land of limpid streams, green valleys and lofty, picturesque escarpments.

The calcareous formation, cleft by the Vézère and its tributaries, is composed of Cretaceous beds approximately horizontal and of varying degrees of hardness (see pl. I); so that overhanging rocks often shelter horizontal galleries and niches. Again subterranean streams have left meandering caverns, some of them several hundred meters in length. These as well as the rock-shelters and open, shallow caves, formed through atmospheric agencies, were inhabited by early man. Some were enlarged or modified and occupied during the Middle Ages. At a safe height in the *roc de Tayac*, one such that withstood successive sieges in the fourteenth and fifteenth centuries is at present used as a restaurant and appropriately named "*au Paradis*."

The earlier explorations at Les Eyzies, Cro-Magnon, Gorge-d'Enfer, Laugerie-Basse, Laugerie-Haute, La Madeleine and Le Moustier are so well known that they are mentioned only in passing. After so long a series of important discoveries, it might well be supposed that the archæological possibilities of the region had been exhausted, yet some of the most important treasures still remained locked in the recesses of the less easily accessible and little known subterranean caverns which penetrate the hills to great depths. The entrances to these caverns are small and invisible from the valley below. Some indeed were completely stopped by hillside débris, leaving no outer trace of their existence. It is not strange that they escaped immediate notice. They were neglected until the early nineties, when Rivière removed some of the floor deposits in the cavern of Les Combarelles that yielded many flint implements, and especially fine bone needles. In 1895, he began work in similar deposits in the cavern of La Mouthe. One day, after penetrating to a considerable depth, he and his companion, the son of Berthoumeyrou, the innkeeper, sat down to rest. In lighting a cigar, the extra light of the match added to the feeble candle light and placed at the proper angle revealed to

one of them what had not been observed before—an engraving on the wall. The discovery was duly announced and marked the beginning of a new epoch in cavern explorations. Not that Rivière's discovery was the first of its kind; but that the two previous finds of a similar nature had not been accepted as authentic. These were in the cavern of Altamira, Province of Santander, Spain, explored in 1879 by Sautuola;* and of Chabot (Gard), explored prior to 1889 by Léopold Chiron. Then followed Rivière's discovery at La Mouthe and that of Daleau in 1896 in the cavern of Pair-non-Pair (Gironde).

The mural decorations at La Mouthe occur in four groups or panels. The first panel is about ninety-three meters from the entrance. The second, four meters farther on, is called the "Hall of the Bison." Seven animals are represented on an area 5.02 meters by 2.6 meters. The third and fourth panels are one hundred and thirteen and one hundred and thirty meters, respectively, from the entrance.

In 1899, Rivière was so fortunate as to find a stone lamp in the floor deposits of this cavern at a point about seventeen meters from the entrance. The pick of the workman broke the lamp into four pieces of which three were immediately recovered. Rivière and two of his men searched for the missing fragment an entire day, but without success. The shallow bowl contained some carbonized matter, an analysis of which led M. Berthelot, the chemist, to conclude that lard was used for lighting purposes. On the base there is an engraving of a wild goat's head and horns. A figure exactly like this was found on the third mural panel already mentioned. This was the fourth lamp to be found in French caverns. The first and second were from the cavern of Monthier (Charente); and the third from the cavern of Coual (Lot). The necessities of men dwelling in dark caverns would be likely to lead to the invention of artificial light, which light made it possible for them to depict the frescoes and engravings on the walls of their abodes.

The past six years have witnessed a succession of remarkable

*Don M. S. de Sautuola. Breves apuntes sobre algunos objetos prehistoricos de la provincia de Santander. 1880, Libreria Murillo, Madrid.

discoveries by Messieurs Capitan, Breuil, Bourrinet and Peyrony, in the caverns of Les Combarelles, Font-de-Gaume, Bernifal and others.

The Combarelles cavern has a total length of two hundred and thirty-four meters, is from one to two meters wide, and high enough to admit of walking upright for most of the way. The engravings begin at a point about one hundred and eighteen meters from the entrance, and occupy both walls for a distance of one hundred meters. Some of the figures are deeply incised; others are mere scratches. In some, the effect is heightened by the application of a dark coloring matter (oxide of manganese). Portions of the walls are covered by a coating of stalactite thick enough in places completely to hide engravings; while in others, the more deeply incised figures are still visible. On areas devoid of incrustations, the figures are fresh and distinct. The artist sometimes had recourse to champlevé; sometimes natural prominences were utilized to add relief to the figures. Of the one hundred and nine engravings of various animals on the walls at Les Combarelles there are some forty equine figures, occurring either singly or in groups, and fourteen of the mammoth. The mural engravings belong precisely to the same school of art as the relief and incised figures from the floor deposits of the shallow caves and rock-shelters, so well known through the works of the earlier investigators. This statement applies equally to all the caverns thus far explored.

The cavern of Bernifal was first explored in 1903. It was discovered by accident. The original entrance near the base of an escarpment is completely obstructed by earth and stones. The present artificial entrance is at a point where the ceiling of the cavern comes close to the surface of the wooded, sloping upland. The descent into the cavern is almost vertical, and made by means of an iron ladder about three meters long. There is a joint in the ladder, the upper portion of which may be inclined and locked so as to secure the interior against vandalism.* Within are three large chambers united by rather

*Most of the prehistoric monuments of France are now the property of the Government and are protected by the enactment and enforcement of wise laws.

narrow corridors. The first is twenty-two meters long, with high ceiling and a maximum breadth of eight meters. The others are not quite so large. The beautiful stalactites overhead have been left undisturbed. Most of the engravings are to be found in the second chamber. They are cut rather deeply into the calcareous walls, and generally coated over with a thin, hard layer of stalactite. Twelve groups numbering in all twenty-six figures have been recognized. These include geometric, triangular signs in addition to various animal figures—reindeer, mammoth, horse, bison, and antelope. Some are simply engraved, others are painted with red ochre and manganese. Many are probably wholly hidden beneath thick mural incrustations. Tectiform signs, the significance of which is unknown, were also met with at Les Combarelles and Font-de-Gaume.

The Font-de-Gaume frescoes and engravings were discovered in 1901 by Capitan and Breuil with the assistance of M. Peyrony, the school principal of Les Eyzies. The entrance is some twenty meters above the valley and near the top of the escarpment (pl. II).

A passage about sixty-five meters long, and much restricted in places, leads to an ample gallery forty meters in length, two to three in breadth, and five to six in height. A majority of the paintings—and Font-de-Gaume is especially rich in paintings—occur on the walls of this gallery and in a little side chamber farther on (fig. 1). The latter contains thirteen remarkable figures, in color, of the bison and a group of reindeer. The coloring matter was red ochre and manganese, either mixed so as to give various intermediate shades or used separately. Both these materials are found on top of the neighboring plateaus. The dimensions of the figures vary from 2.70 meters down to .20 meters. Some are on regular surfaces, while others include natural prominences in such a way as to give the effect of relief. They are veritable frescoes, the whole figure often being covered with paint. Engraving and fresco are usually associated in the same figure. The coloring matter was, in some cases, applied after the engraving; while in others the process was reversed. Again some figures are a piece-work of

engraving and fresco. Some are engraved only. In certain cases the outlines of the animal are simply traced by a single stroke of the brush or pencil, usually in black. Where the contours are filled in, various tints from black to red are usually employed. The outlines are seldom marred by blotches or evidences of an uncertain stroke.

Of the more than eighty figures described already from Font-de-Gaume, forty-nine represent the bison, four the reindeer, four the horse, three the antelope, two the mammoth, one the stag, one *Felis leo*, one *Rhinoceros tichorhinus*, six various signs. A number have not yet been determined.

In their various explorations Messieurs Capitan, Breuil and Peyrony have collected about a hundred drawings of the mammoth. Those of the bison, horse and reindeer are also numerous. On the other hand representations of *Ursus*, *Felis*, and *Rhinoceros* are rare. The engraving of *Ursus spelaeus* on a piece of schist found in the floor deposits of the cavern of Massat (Ariège) has been known since 1867. A similar figure is to be seen on the cavern walls of Les Combarelles. An engraving of *Felis* on a pebble from the cavern of Gourdan (Haute-Garonne) was recently published by Piette. Two mural engravings of *Felis* are known; one at Les Combarelles and the other at Font-de-Gaume. In the latter the entire animal is represented, being characterized by the form of the head, the general aspect of the body, the long, lifted tail and short paws. The animal is probably *Felis leo*, var. *spelaea*, since it is figured somewhat larger than are the four horses forming part of the same group or picture.

One of the most interesting animal representations on the cavern walls of Dordogne is a color drawing of *Rhinoceros tichorhinus*, found at Font-de-Gaume near the group that included an engraving of the cave lion. The figure is not only complete but also exact. The two horns are faithfully indicated, the anterior notably longer and larger than the posterior. The only other representation of the woolly rhinoceros is an indifferent engraving on a piece of stone found in the cavern of Gourdan and recently published by Piette.

The cavern of Font-de-Gaume opens on a narrow valley

tributary to that of the Beune and near their junction. The well-known rock-shelter of Les Eyzies lies across the valley of the Beune. It is visible from Font-de-Gaume, appearing like a black spot on the face of the great escarpment, and only eight hundred meters distant. M. Peyrony* suggests that the two prehistoric communities may have been closely united. His recent researches at Les Eyzies tend to confirm this view.

The shallow cave of Les Eyzies, overlooking the Beune near its junction with the Vézère, opens on a sort of natural platform about thirty-five meters above the bed of the stream. The opening of the cave is wide and high enough to admit the light to its greatest depth, which is twelve meters. The greatest width is sixteen meters. It has a southern exposure, is dry and habitable. Font-de-Gaume was never a place of residence, as is indicated by the absence of floor deposits. About the only objects found there are a few broken gravers with edges dulled in executing the wall engravings, a few pieces of ochre and manganese and one handsome ochre pencil. Why should the artists make residence of a dark subterranean cavern, when by going a short distance they could have an ample shallow cave or rock-shelter facing the south and warmed and lighted by the sun? Such a shelter is Les Eyzies and the enormous quantities of refuse taken from its floor at various periods testify to its use as a place of habitation by generation after generation.

The rock-shelter of Les Eyzies has furnished unusually large quantities of ochre of various tints. Most of the pieces have been scraped to produce a colored powder which was mixed with grease or some liquid, thus forming a paint. In order to pulverize and thoroughly mix the coloring matter, mortars were used. An interesting series of these mortars from Les Eyzies forms a part of the famous Christy collection in the British Museum. Very few mortars have been found in neighboring stations. Besides, ochre pencils exactly like the one from Font-de-Gaume have been found in the rock-shelter of Les Eyzies. Sometimes a flat piece of ochre is cut in the

*Le Dr. Capitan, l'Abbé Breuil et Peyrony. Nouvelles observations sur la grotte des Eyzies et ses relations avec celles de Font-de-Gaume Compte rendu, Congrès préh. de France, 1905, p. 137.

form of a triangle, each angle serving in turn as a pencil point. Some of these pencils are perforated to be suspended, and might well be supposed to form a part of the outfit of the artists who drew in color figures such as that of the two-horned rhinoceros previously mentioned.

It may be that the artists who made their home at Les Eyzies decorated its walls also. Exposure would have obliterated these decorations long ago. Lucky it was for present-day lovers of art and archæology that their troglodyte forebears had the good sense to seek at Font-de-Gaume a more permanent gallery for their masterpieces.

In addition to the four caverns with wall engravings and paintings in the Vézère valley group, one other is now being explored in the Dordogne, viz., the cavern of La Mairie at Teyjat. This large cavern is only two hundred meters distant from the rock-shelter of Mège, discovered in 1903 by M. Bourrinet. In the cavern of La Mairie the floor deposits may be separated into two industry-bearing layers. The upper one of these contains the same industry as the single layer in the adjacent rock-shelter of Mège, except that the latter has furnished archæological material in greater quantities than were found in the deposits of the cavern. The relative positions of the engravings on the cavern walls and the upper layer of floor deposits prove that both belong to the same epoch (Magdalenian). It is also interesting to note that while bones of the reindeer abound in the rock-shelter of Mège, representations of this animal predominate among the mural engravings in La Mairie cavern.

Besides the cavern of Chabot and of Pair-non-Pair, already mentioned, other decorated French caverns explored to date are: Le Figuier (Ardèche) across the river from Chabot, La Grèze and La Calévie (Dordogne), and Marsoulas (Haute-Garonne).

Of caverns with paleolithic mural decorations outside of France, thus far reported, one is in Italy and seven are in Spain.* The most important cavern in the Spanish group is that of Altamira in the north coast Province of Santander, previously

*Altamira, Castillo, Covalanas, Hornos de la Peña, La Haza, La Venta de la Perra and San Isabel, all in the Province of Santander.

mentioned as being the one in which the discovery of mural figures first took place. The genuineness of these figures would have continued to remain in doubt had it not been for similar subsequent discoveries elsewhere.

Messieurs Émile Cartailhac and the Abbé H. Breuil have recently studied with great care the wall paintings and engravings at Altamira. The cavern is a series of large chambers connected by passage ways. There is no evidence of its having been occupied by either man or beast since the close of the Quaternary, at which time the entrance was completely closed by a fall of earth and stones.

A second, recent fall has afforded a new opening to the cavern reached by clambering over the débris that closed the original entrance. The first chamber is divided by means of a mass of fallen stones. The one on the left is forty meters long by twenty meters wide. The one on the right is a sort of corridor connecting with other chambers. Industrial remains of the floor deposits are confined to the entry and the chamber on the left. There is evidence that the cave bear had occupied the cavern before man took possession. Figures, engraved or painted, are found on the walls of every part of the cavern, especially on the ceiling of the chamber on the left near the entrance, where the frescoes are remarkable for their beauty, size, and good preservation—a sort of Sistine chapel representing the *chef d'oeuvre* of perhaps more than one Michael Angelo of that far-off time.

These works of art represent a variety of technique. Some are simple line engravings. Others are more deeply incised. But the engravings are not so numerous as the figures represented in color. Many are done in a single color, either red or black. The most remarkable are the polychrome frescoes similar to those of Font-de-Gaume already described.

The figures are not all animal representations. Many are signs, the significance of which is not known. They do not belong to a single epoch. The superposition of figures, each in a different technique, studied in connection with the relative state of preservation of the various figures, has furnished a key to the order of succession. The same succession is trace-

able in the caverns of France, so that the Abbé Breuil and his colleagues, Messieurs. Cartailhac, Capitan, Peyrony and Bourrinet, have been able to distinguish four distinct phases* in the evolution of mural painting and engraving, all of them being represented in the cavern of Altamira.

The *first phase* includes deeply incised figures representing the animal in absolute profile, *i. e.*, with a single forefoot and a single hindfoot, the outlines being rude and not well-proportioned, and details, such as hoofs and hair, not indicated. The figure of a bison in the corridor on the right is a specimen of this oldest class of wall decoration. Other examples are found at La Grèze (fig. 2), Chabot and Pair-non-Pair.

The paintings of this stage are also in outline, the color being black or red and drawn with a crayon, there being absolutely no effort at modeling. The horse drawn in black on the ceiling of the left chamber is an illustration (fig. 3). Others may be seen at Marsoulas, Font-de-Gaume, La Mouthe, Les Combarelles and Bernifal.

The incised figures of the *second phase* remain deep and broad; but the outlines are more lifelike although often ill-proportioned. All four legs are often represented, the distal ones being almost completely hidden by those nearest the beholder. The hoofs are sometimes represented with great care. As the incisions become less deep they also gain in neatness. In places the effect of bas-relief is given by means of champlevé. The more hairy portions are indicated by incised lines. Engravings of this stage are not numerous at Altamira. They are seen to better advantage at La Mouthe, Font-de-Gaume, Bernifal, and above all at Les Combarelles (fig. 4).

The paintings of this phase evince the first attempts at modeling by shading at various points. Engraving is often combined with the painting. The use of color continues to develop until one arrives at a monochrome silhouette usually in black. The contours are often heightened by engraving. The second phase is represented not only at Altamira but also at Marsoulas, Les Combarelles, Font-de-Gaume and La Mouthe.

*A fifth and closing phase is discernible at Marsoulas, resembling somewhat the work on the painted pebbles of Mas d'Azil.

The engravings of the *third phase* are generally of small dimensions. Many of these are admirable in their execution, as, for example, the bison in the terminal corridor. The entire mural decorations in the cavern of La Mairie at Teyjat are in this style, as are a number from Font-de-Gaume and Marsoulas.

In the domain of painting, the third phase is represented by an excessive use of color, producing a flat effect, thus destroying the modeling that was such an attractive feature of the preceding stage. At Altamira the color employed is red and the drawing is deplorable. As a rule these examples are not well preserved. Those from Marsoulas, in either black or red, are not much better. The best work of this phase is to be seen at Font-de-Gaume and is executed in black or brown. It is often combined with engraving of a high order, done before the color was applied.

In the *fourth phase* the engravings lose their importance. The lines are broken and difficult to follow. The small figures of the mammoth at Font-de-Gaume and of the bison at Marsoulas show this tendency to emphasize detail at the expense of the ensemble.

Paleolithic painting reached its zenith in the fourth phase. The outlines are drawn in black, as are the eyes, horns, mane and hoofs. The modeling is done with various shades produced by the mixing of yellow, red and black. Engraving always accompanies the fresco, serving to emphasize the details. These polychrome figures are seen at their best on the ceiling of the left chamber near the entrance; also at Marsoulas and Font-de-Gaume (pls. III and IV).

Shortly before his death, M. P. Jamin, a well-known Parisian artist, exhibited in the Paris Salon of 1903 a large oil painting inspired by the discovery of these polychrome frescoes. This canvas also formed part of the French art exhibit at the Louisiana Purchase Exposition, St. Louis, in 1904. It represents the cave-dweller artist in the little side chamber of Font-de-Gaume at work on one of the thirteen figures of the bison (see p. 560), while members of his family look on and applaud. In a panel above his head is the unfinished group of reindeer.

It has long been the custom for artists to copy the old masters. M. Jamin has rendered a valuable service both to art and archæology by introducing the modern French school of painters to the earliest school of art developed on what is now French soil. The ages of Phidias and of the Italian Renaissance, viewed in the light of their antecedents, are wonderful manifestations; but not more wonderful than that of the Vézère Troglodyte, a contemporary of the mammoth and rhinoceros, the bison and the reindeer.

## PAPERS READ.

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TOTEMISM IN CALIFORNIA. BY C. HART MERRIAM.

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THE YUMME OR MOURNING CEREMONY OF THE ME-WUK. BY C. HART MERRIAM.

---

ME-WUK MYTHS. BY C. HART MERRIAM.

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NOTES ON THE BLACKFOOT MYTHS. BY CLARK WISSLER

---

NOTES ON THE TAKELMA INDIANS OF SOUTHWESTERN OREGON. BY EDWARD SAPIR.

---

REPORT ON THE BOOK ON MARYLAND FOLK-LORE. BY (MISS) ANNE WESTON WHITNEY.

---

CHEROKEE STAR LORE. BY STANSBURY HAGAR.

---

PHILIPPINE MARCHEN. BY W. W. NEWELL.

---

RECENT ACTIVITY IN FOLK-LORE IN MISSOURI. BY W J McGEE

---

NOTES ON PUEBLOAN HOUSE CONSTRUCTION. BY FREDERICK S. DELLENBAUGH.

THE ARCHEOLOGY OF MANABI, ECUADOR. BY MARSHALL H. SAVILLE.

---

NOTES ON THE ANDEAN CULTURES. BY MARSHALL H. SAVILLE.

---

NOTES ON THE OCCURRENCE OF THE MINERAL UTAHLITE AS A PREHISTORIC GEM. BY HENRY MONTGOMERY.

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THE ART OF GLAZING AMONG THE ANCIENT PUEBLOS. BY EDGAR L. HEWETT.

---

THE RELATION OF PUEBLO INDIANS OF THE RIO GRANDE VALLEY TO THE ANCIENT CLIFF DWELLERS OF THE ADJACENT PLATEAUS. BY EDGAR L. HEWETT.

---

RECENT ARCHEOLOGIC WORK IN MISSOURI. BY W J McGEE.

---

RECENT GEOLOGICAL CHANGES AS AFFECTING THEORIES OF MAN'S DEVELOPMENT. BY G. FREDERICK WRIGHT.

---

HARNESS MOUND EXPLORATIONS. BY WILLIAM C. MILLS.

---

RECENT DISCOVERIES AT A PREHISTORIC INDIAN VILLAGE SITE AT MARINER'S HARBOR, STATEN ISLAND. BY ALANSON SKINNER.

---

HEREDITY IN HEAD FORM. BY FRANZ BOAS.

SOME RACIAL PECULIARITIES OF THE NEGRO BRAIN. BY ROBERT BENNETT BEAN.

---

BRAIN AND EDUCATION. BY THOMAS M. BALLIET.

---

SELECTION AND ELIMINATION BY IMMIGRATION. BY MAURICE FISHBERG.

---

CERTAIN ASPECTS OF HUMAN HEREDITY. BY W J McGEE.

---

RECENT RESULTS OF ANTHROPOLOGIC INVESTIGATIONS BY THE UNIVERSITY OF CALIFORNIA. BY A. L. KROEBER.

---

THE SANDPAINTING AMONG THE LUISENOS AND DIEGUENOS MISSION INDIANS OF SOUTHERN CALIFORNIA. BY CONSTANCE GODDARD DUBOIS.

---

NOTES ON CRETAN ANTHROPOLOGY. BY CHARLES H. HAWES.

---

A PLEA FOR THE STUDY OF THE HISTORY OF MEDICINE AND THE NATURAL SCIENCES. BY BERTHOLD LAUFER.

---

ELLIS ISLAND AS A FIELD FOR ANTHROPOLOGICAL STUDY. BY K. S. KENNARD.

---

GEOMETRICAL DESIGN IN PRIMITIVE DECORATION. BY K. D. JESSEN.

---

STUDIES IN THE LIFE HISTORY OF PRIMITIVE ART. BY (MISS) H. NEWELL WARDLE.

ABORIGINAL RACE COURSE. BY WILLIAM P. BLAKE.

---

THE NEBRASKA LOESS MAN. BY E. H. BARBOUR.

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Papers were read by title as follows:

FOC-LOR MEXICANO. BY NICOLAS LEON.

---

THE VOLCANO OF BELL SPRINGS. BY (MRS.) R. F. HERRICK.

---

ON THE PREPARATION OF BONE FOR CERTAIN IMPLEMENTS. BY (MRS.) R. F. HERRICK.

---

WITCHCRAFT IN NORTHERN NEW JERSEY IN THE NINETEENTH CENTURY. BY WILLIAM NELSON.

---

THE USE OF WATER WITCHES IN RAILROAD BUILDING. BY WILLIAM NELSON.

---

MAYA RELIGION. BY A. M. TOZZER.

---

ON THE ABORIGINAL USE OF TURQUOISE ON THE AMERICAN CONTINENT. BY GEO. F. KUNZ.

---

RACIAL CHARACTERISTICS OF THE HUMERUS. BY ALES HRDLICKA.

---

THE DISAPPEARANCE OF BLOND TYPES FROM THE AMERICAN POPULATION. BY MAJOR C. E. WOODRUFF.

THE DECREASE OF THE INDIAN POPULATION. BY JAMES MOONEY.

---

IRON AND COPPER METALLURGY IN THE KASAI. BY S. P. VERNER.

---

THE PYGMIES AND THE ANTHROPOID APES. BY S. P. VERNER.

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PHALLIC INFLUENCE IN BANTU ART MYTHOLOGY. BY S. P. VERNER.

---

THE FRENCH-EGYPTIAN MEDAL IN COMMEMORATION OF THE SAVANTS WHO ACCOMPANIED GENERAL BONAPARTE INTO EGYPT. BY COLONEL PAUL BECKWITH.

---

THE ETHNOLOGY OF THE TEETH. BY ALTON H. THOMPSON.

---

SOME SUGGESTIONS IN REGARD TO PRIMARY INDIAN MIGRATIONS IN NORTH AMERICA. BY CYRUS THOMAS.

---

THE PHYSIOLOGY OF SECOND SIGHT. BY SAMUEL S. LAWS.

---

A MAIN FACTOR IN REMEDYING DEAFNESS. BY SAMUEL S. LAWS.

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THE TRUE OBJECT OF VISION. BY SAMUEL S. LAWS.

## SECTION I.

# Social and Economic Science.

ADDRESS

BY

# IRVING FISHER,

VICE-PRESIDENT AND CHAIRMAN OF SECTION I FOR 1906.

## *WHY HAS THE DOCTRINE OF LAISSEZ FAIRE BEEN ABANDONED?*

Perhaps the most remarkable change which economic opinion has undergone during the last fifty years has been the change from the extreme *laissez faire* doctrines of the classical economists to the modern doctrines of governmental regulation and social control. And yet there has been very little attempt to explain why *laissez faire* has been so generally abandoned. Its abandonment has been gradual and almost unconscious, not so much the result of any rival abstract doctrine, as the cumulative effect of experience, which in hundreds of individual cases has brought men face to face with the practical limitations of the let-alone policy. The movement is fast bringing us back to the old view by virtue of which economics was first named *political* economy.

The revival of governmental activity in economic affairs is due to causes which are partly political and partly economic This paper has to do chiefly with the economic causes and we shall, therefore, merely note in passing the chief political aspects of the problem. One reason for the extension of governmental control of industry is the growing strength of governmental control in general and of popular confidence in it. *Laissez faire* was a natural doctrine in a time when governments were weak and inefficient. Change of power has brought change of the theory of power. Compulsory workmen's in-

surance we find in the strongly developed German Empire; railway rate regulation follows increased power and centralization of government. It may even be said that much of the modern government regulation of industry resulted from the attempt of governments to extend its powers in self-defense. It has been felt, for instance, that if the government did not control the railroads, the railroads would control the government. Government regulation here has taken on the aspect of a struggle for supremacy. Just as England feels the necessity of having a navy equal to the combined navies of several other European powers, so governments feel that they must overtop the corporate aggregations of wealth with which they may have to cope.

Were there space we might discuss the question how far the movement toward governmental interference can profitably be pushed. The doctrine of socialism lies at the extreme opposite pole from the doctrine of *laissez faire*, and we are moving toward socialism dangerously fast. Yet there are insuperable obstacles to the success of socialistic projects. Governmental power and efficiency are limited and, when one class of society attempts actually to rule another, there is always a tendency to corruption, inefficiency, lack of adaptability to new conditions, and abuse of power. Socialism can not be put in practice without opposition, and to maintain itself socialism must hold the opposing class in subjection. Nominally this subjection would be a benevolent paternalism, but in political history it is the universal experience that the party in power, to entrench itself against attacks, soon usurps more power, employs indefensible and oppressive methods, and tries to establish itself in the enjoyment of special selfish privileges.

Our present purpose, however, is to study, not the political, but the economic side of the problem. The doctrine of *laissez faire* is that governmental interference, in economic matters at least, is unnecessary and harmful. Sometimes it is added as a corollary that not only should government let individuals alone, but also that individuals should let each other alone. "Live and let live" and "Each for himself" are the mottoes of this type of individualism. The advocates of extreme *laissez faire* main-

tain that one class is not justified in imposing its tastes upon another. They say we must not meddle with our neighbors' affairs, even if they are wasting their lives in what appears to us trivial, useless, or positively harmful gratifications. Those who love art, science or literature have no right, we are told, to criticize those who are bored by these things, but love prize-fighting, fast horses, fast society, or high living.

The reasoning by which these individualistic doctrines were supported may be briefly stated in two propositions: first, each individual is the best judge of what subserves his own interest, and the motive of self-interest leads him to secure the maximum of well-being for himself; and, secondly, since society is merely the sum of individuals, the effort of each to secure the maximum of well-being for himself has as its necessary effect to secure thereby also the maximum of well-being for society as a whole.

In the light of the experience of the last fifty years, it is not difficult to see wherein each of these two propositions is in error. First, it is not true that each man can be trusted to pursue his own best interests. Some men need enlightenment, owing to ignorance of what constitutes their best interests, and others need restraint, owing to lack of self-control in following them. The necessity for both enlightenment and restraint has always been recognized in the case of children, and an examination of actual conditions will show that they apply—often with equal force—to adults.

Liberty is certoinly indispensible in a healthy society, but liberty insensibly verges upon license. While most of us would still agree that sumptuary laws are ill-advised, there is certainly good ground for maintaining that the liquor traffic should be put under some restraint, even if only by high license. It is not true that the drunkard is the best judge of what is for his own well-being and that of his family, and it is still less true that even when he thoroughly recognizes his failings he will have the self-control to act upon that knowledge. Hence the liquor problem becomes a social as well as an individual question, Again, it is not true that ignorant parents are justified in imposing their ideas of education upon their children; hence the

problem of child-labor, instead of concerning only the individual as was at one time thought, has important and far-reaching relations to society as a whole. The same principles apply to the restraint of gambling, vice, the suppression of indecent literature, the compulsion upon landlords to make tenements sanitary, and many other forms of governmental regulation.

Even where governmental intervention is impracticable, or inadvisable, there will still be good reason for attempting betterment of conditions through the influence of one class upon another; hence come social agitations and the efforts of one class to educate or instruct another. On this principle are based the great modern movements for human betterment as exemplified by the Society for the Study and Prevention of Tuberculosis, the Society for Sanitary and Moral Prophylaxis, the National Civic Federation, the American Institute of Social Service, the National Child Labor Committee, temperance societies, college settlements, district nurse associations and other organizations.

Strange as it may seem to those of us interested in these movements to-day, the fact is that a generation ago many of them would have been regarded by the dominant Manchester School not only as impracticable, but as unnecessary and possibly harmful. The adherents of this school seemed to treat the difference between knowledge and ignorance as a mere difference in opinion, with which the government has no more concern than with difference of religious creeds. It is certainly true that the attempts of governments to impose what is regarded by the ruling class as the "true religion" upon the entire people have always proved ill-advised; the recognition of this has produced the modern sentiment of religious toleration. But we are carrying toleration too far when we refuse to correct errors which science demonstrates to be false. There are doubtless millions of persons to-day who jeer at the idea that indiscriminate spitting is dangerous to public health, but it would be silly to allow their ignorant prejudice to prevail. The bacteriologist knows what the ignorant do not know, and every effort should be made to pass down this knowledge to the masses as soon as possible after it is discovered. We can not

let any dogma of *laissez faire* prevent us from checking suicidal ignorance.

The world consists of two classes—the educated and the ignorant—and it is essential for progress that the former should be allowed to dominate the latter. But once we admit that it is proper for the instructed classes to give tuition to the uninstructed, we begin to see an almost boundless vista for possible human betterment. Instead of regarding the present state of society as a normal and desirable one because each man naturally "seeks his own best interests," we permit ourselves to judge each actual case by our own ideal standard. This standard may differ widely from the average of actual usage. We must always distinguish between the ideal or *normal*, and the real or *average*.

The average represents merely conditions as they are; the normal represents conditions as they ought to be. Yet nothing is more common than confusing the two. In fact, in most anthropometric or physiologic tables, the word "normal" is used almost synonymously with "average." The normal height of man, his normal weight, his normal length of life, his normal diet, strength, etc., are all identified with the average.

In this way all question of possible improvement is begged. We are stopped at the outset from asking, for instance, whether men in general are too stout, for the average weight of mankind is *assumed* as "normal." The absurdity of such procedure becomes apparent as soon as we consider cases in which, by common consent, the average and the normal are held to be distinct. For instance, the average adult man certainly does not have normal teeth, for they are usually half decayed; nor normal hair, for he is usually half bald; nor normal posture, for he is usually round-shouldered. Average health is below normal health, average morality below normal morality. In the absence of evidence we have no right to assume that the average and the normal are identical, even when we lack the data on which to base an opinion. It is only recently, and in consequence of the movement against tuberculosis, that experts have come to realize how widely different is the average air we breathe from air which is normal for human respiration, and that

investigation has shown the average diet, in America at least, to be abnormally nitrogenous. In view of such revelations we should be open-minded enough to accept evidence—should it be offered—that the average span of life is less than half the normal span, and the average efficiency less than half the normal efficiency.

Those who habitually confuse the normal and the average are prevented from seeing the possibility of progress. They take the position, as unscientific as it is obstructive of progress, that "whatever is is right," presumptively at least, and brand every one who deviates from the average as an eccentric or a crank. The confusion between the normal and the average thus leads to the confusion between the eccentric and the pioneer. An eccentric or a crank is properly a person who deviates from the *normal*, and is almost the opposite of the pioneer, who deviates from the *average*, but toward the normal.

Discrepancies between the average and the normal may apply —in fact, do apply—to the economic side as well as to other sides of life. But this the *laissez faire* doctrine denied. The world as it is was thought to be nearly, if not absolutely, the best world possible. One example of this complaisant assumption was in the use of the term "utility" to signify the intensity of desire that men have for things. So far as I know, the only writer who has attempted systematically to distinguish between the desires of men as they are and as they should be, is Pareto, who for this purpose suggested a new term—ophelimity—to replace "utility" as applied to man's actual desires, reserving for the term "utility" its original sense of what is intrinsically desirable. Thus, to an opium fiend opium has a high degree of ophelimity, but no utility. Economists have not yet laid sufficient emphasis on the distinction between true utility and what Pareto calls ophelimity. A whole range of problems of social betterment is opened up through the distinction. Economists have received with derision the suggestions of reform of Ruskin. But, however impracticable his specific proposals, his point of view is certainly saner than that of most economists; for, as Ruskin has pointed out, it is absurd to regard as equivalent a million dollars of capital invested in opium culture, and a million dollars invested in schools.

But there remains to be considered a second fallacy in *laissez faire*. Not only is it false that men, when let alone, will always follow their best interests, but it is false that when they do, they will always thereby best serve society. To Adam Smith it seemed self-evident that a man served society best who served himself best—though he would certainly have admitted that the rule had exceptions in the case of thieves, assassins and others who are obviously enemies of society. But the extent to which the classical "economic harmonies" were pushed by some writers, while not including such persons as thieves among beneficent workers, was, nevertheless, astonishing. Herbert Spencer's advocacy of freedom of private coinage is well known, though any one familiar with "Gresham's law" knows how chimerical such an institution would be. A still more astonishing suggestion is that which Molinari is reputed to have made at one time, namely, that even the police function of government should be left to private hands, that police corps should be simply voluntary vigilance committees, somewhat like the old-fashioned fire companies, and that rivalry between these companies would secure better service than that now obtained through government police!

If we stop to classify the social effects of individual actions, we shall find that they fall into three groups: (1) those actions which benefit the individual himself and have no effect upon others; (2) those actions which benefit the individual and at the same time benefit society; (3) those actions which benefit the individual while at the same time they injure society. It is the third group which the *laissez faire* doctrinaries have overlooked, and especially that part of the third group in which the injury to society outweighs the benefit to the individual. As Huxley said:*

"Suppose, however, for the sake of argument, that we accept the proposition that the functions of the state may be properly summed up in the one negative commandment—'Thou shalt not allow any man to interfere with the liberty of any other man'—I am unable to see that the logical consequence is any

* Life and Letters of Thomas H. Huxley," by Leonard Huxley, Vol. I., pp. 384–5: Appleton, New York, 1900

such restriction of the power of government, as its supporters imply. If my next-door neighbor chooses to have his drains in such a state as to create a poisonous atmosphere, which I breathe at the risk of typhoid and diptheria, he restricts my just freedom to live just as much as if he went about with a pistol threatening my life; if he is to be allowed to let his children go unvaccinated, he might as well be allowed to leave strychnine lozenges about in the way of mine; and if he brings them up untaught and untrained to earn their living, he is doing his best to restrict my freedom, by increasing the burden of taxation for the support of gaols and work-houses, which I have to pay.

"The higher the state of civilization, the more completely do the actions of one member of the social body influence all the rest, and the less possible is it for any one man to do a wrong thing without interfering, more or less, with the freedom of all his fellow citizens."

In the examples given by Huxley, the acts complained of are injurious not only to society, but to the individual. But even when the act of an individual is actually for his own benefit, it may not be for the benefit of society. The paradox that the intelligent actions of a million individuals, each attempting to better his condition, may result in making the aggregate condition of the million worse, is illustrated by considering the effect of individual action in the case of a burning building. When a theater is on fire, thousands of frantic individuals are struggling to get out. In the panic, it is doubtless to the best interest of any particular individual to struggle to get ahead of the others; if he does not, he is far more apt to be burned. And yet nothing is more certain than that the very intensity of such efforts in the aggregate defeat their own ends. The reason is that the effect of the effort is chiefly relative; so far as one pushes himself forward he pushes others backward.

Numerous examples exist of actions which benefit the individual but injure society, or benefit a part of society but injure society as a whole. Thus, the city of Chicago, in tapping the Great Lakes for its new sewerage system, has tended to influence the level of those lakes and thereby affect economically a large territory, including several states of the Union and also Canada.

It has been estimated that the level of the lakes may be affected as much as six inches.

One reason for federal interference in irrigation is that the water supply is often controlled by citizens of one state, while the land belongs to another state or to the United States, and co-operation between the two is difficult to secure. Water, in the arid lands of the west, is a prime requisite, and without it the lands have no value. From one point, Mt. Union, in the Yellowstone Park, three rivers begin—the Missouri, the Columbia and the Colorado—flowing into the Gulf of Mexico, the Pacific and the Gulf of California, and through a large number of states and a vast extent of territory. The mutual interests of the riparian owners and those affected by irrigation could scarcely be adjusted merely through the play of individual interests.

Similarly, the act of one individual in destroying forests influences climate and water supply and thereby affects other individuals in distant parts. Where individuals in the community are allowed to seek their own interests the destruction of forests in some regions inevitably follows.

A like effect was seen a few years ago in the case of the seal dispute between the United States and Great Britain. The play of individual motive in this case tended to the actual extinction of seals, and could only be curbed by the mutual agreement of nations to prevent pelagic sealing.

Individual action cannot be trusted to provide fireproof or slow-burning construction as required in a crowded city; for the individual, although interested in protecting himself from his neighbors' fires, is not interested in protecting his neighbors from his own fires; hence the necessity and justification for city fire ordinances. Similarly, soft coal, in such cities as Denver, St. Louis and Pittsburg, constitutes a veritable nuisance to the entire city; and yet the individual factory owner is undoubtedly following his own best interest in not substituting hard coal or using expensive smoke-consumers. Such protective measures would redound greatly to the benefit of the community, but only slightly to his own benefit; hence the necessity and justification for smoke ordinances. Individual action would never give rise to a system of city parks, or even to any useful system of

streets. And where parks exist, as in the case of Battery Park, New York, there is a constant tendency for those seeking their individual interests to encroach upon them. In Hartford and other cities certain parks have in this way gradually disappeared, much to the damage of the public.

In the cases mentioned, of a conflict between social and individual interests, legal restraints become necessary. But there are many examples in which, for one reason or another, legal restraints are impracticable. This is particularly true in cases where a number of nations are concerned. There can be no question, for instance, that the standing armies and great navies are an almost intolerable burden in Europe, and that their existence has tended to increase the cost of our own army and navy, three thousand miles away. Nevertheless, in the absence of any central international authority or mutual agreement to bring about disarmament, it must be confessed that it is to the interest of Germany or France each individually to keep up its military equipment to a level comparable to that of its neighbors. Yet the aggregate effect of international competition for military power is to cancel itself out; the advantages and disadvantages are purely relative. The nations are in a mad race each to excel the other. Their object being purely one of relative advantage, such advantage can be shifted from one to the other but cannot accrue to all. A general increase in relative advantage is a contradiction in terms, so that in the end the racers as a whole have only their labor for their pains.

An economic example of the same international character, and one which received very scant attention, is found in the increase of the monetary metals. The production and distribution of gold and silver is the effect of individual action, each person seeking his own best interests. Yet the aggregate effect upon these individuals may be injurious. The injury referred to is not the imaginary injury of an "unfavorable balance of trade" which was the bugbear of the mercantilists, but the exact opposite. A nation which increases its stock of money is always and necessarily a loser. This increase costs the nation either labor of mining or commodities sent out of the country, and for this cost there is no return whatever. To assume that the increase

of money is itself a valuable return is to commit the fallacy of inflationism. Money is a very peculiar commodity. A general increase of other commodities is an advantage to society, but a general increase of money is not. The inflationist reasons that if a government can enrich one person by printing paper money and bestowing it upon him, it has only to do the same for everybody in order to enrich the nation. The paper-money delusion is too well understood to require comment. It is, however, not always perceived that precisely the same reasoning applies to all inflation, even the inflation which nature herself creates when she unlocks her hoards of buried treasure. The United States now has $33 of money per capita as against $22 a few years ago, but we are no better off on that account. The smaller amount of money is as useful in exchange as the larger amount. There are, of course, transition evils in contracting or expanding the currency, but so long as the price level remains constant or certain, the absolute number of dollars of the circulating medium is a matter of indifference. It follows that any effort expended in increasing the stock of money is wasted effort, an effort without a return. This waste is a necessary concomitant of monetary individualism.

A not dissimilar case, and one which is now causing much discussion, is that of railroad rates. Those who have examined the working of competition in railroad transportation recognize the fact that this competition is of the variety called "cut-throat competition," and that no stable or normal rates for transportation, under which capitalists will consent to invest in railway-building, can occur through such competition. Those who advocate competition as a cure for the evils of railroad rates do not appreciate the mechanics of the problem. The effect of competition is to bring rates down to the cost of operation; it leaves no provision for interest on capital sunk in the enterprise. If the cost of operation is one cent per ton-mile, whereas two cents are required to include enough revenue to pay interest on original cost, rates under competition will inevitably sink below the two-cent level to the one-cent level. For if we assume that the two-cent rate is for a moment the ruling rate, it is clear that it would pay any individual competitor to cut under that rate in

order to divert traffic away from his rivals. But as soon as he cuts below it, all the others must do likewise or lose their traffic. This competition is merely self-defense, and yet its ultimate effect is to injure, not benefit, all of the roads who engage in it. It is *cut-throat* competition. In order that rates may be maintained at the two-cent instead of the one-cent level, either competition must be absent, or it must be partial or imperfect. In the actual railroad world competition is usually present at some points and absent at others. The consequence of this mixture of competition and monopoly is that rates will be determined differently for some points than for others, and this constitutes what is called local discrimination. In a régime where monopoly is present, discrimination, not only of this local character, but discrimination as to persons and as to commodities carried, is a natural and inevitable result. It is not, of course, a desirable result; but it is no more undesirable than is the cut-throat competition which is the other horn of the dilemma. This cut-throat competition discourages the investment of capital in new railroads, and the shippers and consumers must in the end suffer. This dilemma between the evils of monopoly and of competition leads to governmental regulation, though the efficacy of this remedy is not all that could be desired. It is not our purpose to discuss the best solution of so difficult a question. We are merely concerned in pointing out that this railroad-rate problem is partly due to cut-throat competition and that cut-throat competition is one more example of the suicidal effects of blindly following individual self-interest.

Numerous other examples might be given; we shall, however, content ourselves with one. As John Rae has pointed out, there exists a species of subtle competition in private expenditure, due to social rivalry—the desire for distinction through wealth. It has frequently been remarked among ladies' social clubs which begin with simple entertainments, that each successive hostess attempts, almost unconsciously, to surpass her predecessor in the entertainment offered. Beginning with tea and cake, the club ends with elaborate and expensive collations, until it produces a heavy drain upon the resources of its members. In precisely the same way, on a larger scale, there is laid a heavy

burden upon us all through the social rivalry of individuals. I we study the history of Newport or similar fashionable resorts, we find that social racing has gradually resulted in setting a pace which only the most wealthy can keep up, and that even for them expenditure represents cost rather than satisfaction. This cost often takes the form of producing fictitious values on articles merely because they are "exclusive." As John Rae says:*

"A dish of nightingale's brains could scarcely be a very delicious morsel, yet Adam Smith quotes from Pliny the price paid for a single nightingale as about £66. According to Suetonius, no meal cost Vitellius less than £2,000. * * * Thus Adam Smith reckons the cost of some cushions of a particular sort used to lean on at table, at £30,000."

Nor do we need to draw our examples from ancient Rome. The "History of Luxury" by Baudrillart will show the tendency to produce luxury out of social rivalry in all ages. It was only recently that an American in London gave a dinner party which was said to have cost $8,000. The table was placed in a large Venetian gondola set in the midst of an artificial lake, while in a smaller gondola near by a band was stationed.

Much has been said of late about the importance of living the simple life, but so far as I know there has been no analysis to show why it is not lived. This analysis would reveal that the failure to live it is due to a kind of unconscious cut-throat competition in fashionable society. When San Francisco was destroyed by earthquake and fire, much comment was made upon the fact that many did not feel their losses as much as might have been anticipated. One reason for this result is doubtless found in the fact that the losses were not relative. Had a single individual found himself suddenly reduced from a palace to a tent, his sense of loss and discomfiture would have been great. He could no longer return social entertainment among his former associates; he would feel "out of it," and envy would gnaw at his breast. But after the San Francisco catastrophe there was little place for envy; all were in the same boat. There was no relative loss, there was only the absolute loss of creature comforts, and

*"Sociological Theory of Capital," by John Rae, ed by C. W. Mixter; MacMillan, 1905, p. 247.

strange as it may seem to one who has not considered it, the absolute loss is the smaller of the two.

It is hard to overestimate the tax which is laid upon society through social racing. We are not conscious of this weight, because, like the weight of the atmosphere, it is always pressing upon us. The New York business man buys a silk hat as a matter of course. He does not think of its cost as a tax laid on him by society. He is satisfied because the hat fills a want, and he does not consider how that want originated. It is only when the tax varies by change of place, just as when atmospheric pressure varies by ascending a mountain, that he is at all aware of its existence. If he removes to a smaller town where social racing is less intense and the leaders in the race are unable to set so high a pace, he finds the tall hat no longer *de rigueur*. He drops off this and numerous other expenses and feels himself that much better off. A gentleman recently refused a salary of $7,000 in New York, preferring $4,000 in a smaller town, feeling that he could buy no more real satisfaction with the former than with the latter. The extra $3,000 meant simply that it would cost more to keep up with his neighbors.

The burden of social racing is laid not only on the rich but upon all classes. A milliner in New Haven recently thought to avoid competing with existing fashionable millinery establishments by catering to the trade of shop girls. To his surprise, he found that the tyranny of fashion was quite as strong among them. He attempted to put on sale a large number of $5 and $6 hats, but found great difficulty in disposing of them, whereas the few $15 and $16 hats met with a very ready sale. The shop girls wanted these hats to "be in the swim." Recently, in France, a whole family committed suicide because they had lost the capital which they considered necessary to keep their social position.

Many ingenious arguments have been made to justify luxury and in some of them there may lie truth. The fact that luxurious expenditure can be so readily cut down in hard times provides a sort of buffer against want and famine. The relations of luxury to the growth of population deserve careful study. But whatever the indirect benefits of luxury, certain it is that it

forms a tax upon society, and a heavy one. It seems also true that, where luxury is greatest, civilization decays.

Were there more space we might discuss remedies for this social racing; but we must content ourselves with merely describing the phenomenon. It exemplifies the manner in which the self-seeking of each may create a burden for all.

From this and the other examples which have been reviewed we see that the mechanics of individualism is not so simple as the individualists have assumed. The old individualism requires two corrections: first, the individual may often be interfered with in his own interest, because either of his ignorance or his lack of self-control; secondly, even when an individual can be trusted to follow his own best interests, it cannot be assumed that he will thereby best serve the interests of society. A recognition of these two facts is essential not only to clear thinking, but as preliminary to any practical solution of the great problems of human betterment. We are doubtless to-day in danger of too much socialistic experimentation; but nothing can be gained and much may be lost by ignoring or condoning the opposite evils of individualism. In fact, the menace of socialism can best be met if we understand and acknowledge the evils which it is intended to remedy. The preliminary to remedy is diagnosis, and an accurate diagnosis will save us from the error of both extremes—the extreme, on the one hand, of an overdoes of socialism, and the extreme, on the other hand, of omitting all medication whatever.

## PAPERS READ.

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THE EVOLUTION OF PROPERTY. BY LOGAN G. MCPHERSON, NEW YORK CITY.

---

THE CONCENTRATION OF WEALTH. BY HENRY LAURENS CALL, WASHINGTON, D. C.

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METHODS OF ASCERTAINING THE COST OF TRANSPORTATION. BY JOHN B. DAISH, WASHINGTON, D. C.

---

COMPETITION VERSUS COMBINATION OF RAILROADS AS AFFECTING THE BASIS OF RATEMAKING. BY H. G. BROWN, YALE UNIVERSITY.

---

PSYCHIC FACTORS IN THE FLUCTUATION OF PRICES. BY RICHARD T COLBURN, NEW YORK CITY.

---

ECONOMIC AND SOCIAL CONDITIONS OF PORTO RICO. BY JOHN L. HOGAN, NEW YORK.

---

THE CHARTER AND WORK OF THE BOARD OF EDUCATION OF ST. LOUIS. BY CALVIN M. WOODWARD, ST. LOUIS.

---

ETHICAL TRAINING FOR EFFICIENT CITIZENSHIP BY FELIX ADLER, NEW YORK.

TRAINING FOR PHYSICAL EFFICIENCY AS AN AIM OF EDUCATION. BY G. O. BREWSTER, NEW YORK.

---

STANDARDS OF SOCIAL EFFICIENCY IN SCHOOL POLICY. BY JOHN FRANKLIN CROWELL, NEW YORK.

---

SOME RESULTS OF RESEARCH IN CHILD-EMPLOYING INDUSTRIES. BY OWEN R. LOVEJOY, ASSISTANT SECRETARY NATIONAL CHILD LABOR COMMITTEE.

---

NEWS SERVICE AND POLITICAL SCIENCE. BY FRANKLIN FORD, GENERAL NEWS OFFICE, NEW YORK CITY.

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THE RATE OF SICKNESS AS DETERMINED BY THE COMPANIES DOING HEALTH INSURANCE IN THE UNITED STATES, PARTICULARLY THE EXPERIENCE OF THE TRAVELERS INSURANCE COMPANY OF HARTFORD. BY HIRAM J. MESSENGER, HARTFORD, CONN.

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TWO NEGLECTED SUBJECTS OF SOCIAL ECONOMY, INCLUDING INTERMENT AND CREMATION CONSIDERED FROM SANITARY AND SENTIMENTAL STANDPOINTS. BY (MRS.) L. OSBORNE TALBOTT, WASHINGTON, D. C.

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RELATION OF DEATH RATES AND BIRTH RATES. BY CHARLES E. WOODRUFF, U. S. A., PLATTSBURG, N. Y.

---

THE BRAIN AND EDUCATION. BY THOMAS M. BALLIET, NEW YORK UNIVERSITY.

SECTION K.

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# Physiology and Experimental Medicine.

ADDRESS

BY

# WILLIAM T. SEDGWICK.

VICE-PRESIDENT AND CHAIRMAN OF SECTION K FOR 1906.

## *THE EXPANSION OF PHYSIOLOGY.*

Looking forward into the far future, we may perhaps dimly discern the day when morphology and physiology will again join hands * * * but that day is as yet most distant.

When Dr. Michael Foster, the eminent physiologist, was writing the lines quoted above, the two grand divisions of biology to which he refers seemed separated as if by a great gulf. In England and America morphology was the reigning favorite and in the higher institutions of learning physiology as such hardly existed. Both zoology and botany had come almost everywhere to mean morphology, and morphological problems were the popular themes of the day. Even in medical schools, physiology was as yet generally denied an independent existence, being commonly appended to or combined with the chair of anatomy, *i. e.*, one of morphology.

Dr. Foster was writing in the early eighties, and those who, like myself, can recall the conditions of biological teaching and research at that time will testify that his words were justified. It is true that a full professorship of physiology had been established in the Harvard Medical School in 1876, and that a brilliant young physiologist, one of Foster's own pupils, in the same year assumed the professorship of biology at Johns Hopkins. And yet I distinctly remember how strange and how full of chemistry and physics the first edition of Foster's physiology seemed as it was shown to me in 1876 by my professor of com-

parative anatomy, and also how two years later I studied physiology in the medical school of one of our leading universities for a whole season, under a young physician of more than ordinary ability and promise, without once seeing a demonstration—still less doing an experiment. The class simply recited—upon so many pages of Dalton's "Human Physiology."

All this was the more remarkable because, according to Dr. (now President) G. Stanley Hall, physiology was at that very time "'The' German Science"—a fact stated and emphasized by Dr. Hall by the title of one of a series of contemporary essays which, re-read to-day, almost cause one to regret that the author abandoned the career of literature for that of administration. (*Cf.* "Aspects of German Culture," by G. Stanley Hall, 1881.)

"Physiology," says Dr. Hall, "has been characterized as just now preeminently *the* German science. This is probably true, whether it means that German physiologic methods and results are less known in other countries than those of other sciences, or that they reflect more peculiarly the national characteristics. Till Foster's text-book appeared, very little was known in England and America of German physiology, save by specialists who themselves had studied in Germany. * * * Fick terms physiology, 'the highest and most fruitful generalization of the collective natural sciences.' Czermak, who devoted his wealth to building and equipping a magnificent laboratory and lecture room and his time to the end of his life to the popularization of physiology, was never weary of insisting that it should be taught in every high school. Once more, evolution in the sense of Darwin or Haeckel is far from being a finality for the physiologist. It is for him rather a morphological assumption that all animals and men belong to one family; and he defines his science with Pflüger as the chemistry and physics of living matter."

Physiology in Great Britain and America had, in fact, so far lagged behind that the publication of Foster's text-book with its revelation of some of the German physiology of the day created a real sensation. In the English-speaking countries morphology was everywhere the fashion and biologists, whether botanists or zoologists, were then, almost without an exception,

morphologists. Even ten years after Foster's book appeared, Huxley, who had himself previously defined the grand divisions of biology as morphology and physiology rather than zoology and botany, speaks of zoology, in his Queen's jubilee essay on "The Progress of Science" 1887), as if this were really morphology when he writes: "It is only in the present epoch that zoology and physiology have yielded any great aid to pathology and hygiene."

When Foster's text-book appeared, descriptive zoology and embryology were already rivals in popularity, and the appearance in 1880 of Balfour's "Comparative Embryology" made this subject for zoologists almost a passion. And yet to-day Balfour's then fascinating work seems strangely descriptive and somewhat over anxious after merely structural homologies. In his "Introduction" Balfour, while defining embryology as covering "the anatomy and physiology of the organism during the whole period included between its first coming into being and its attainment of the adult state," is carefully to add: "The present treatise deals only with the embryology of animals, and the science is moreover treated from the morphological or anatomical rather than the physiological side." So much was embryology the fashion of the day that Foster himself issued with Balfour a well-known volume on the "Embryology of the Chick," and this too as a morphological, not a physiological, treatise. In view of these evidences of Balfour's preoccupation with morphological problems, it is interesting to learn from Dr. A. C. Haddon, one of his students, that Balfour always looked upon this preoccupation as temporary and that he intended to devote himself eventually to comparative physiology. Huxley again omitted all reference to physiology in embryology when in 1878 he defined the latter as "an account of the anatomy of a living being at the successive periods of its existence, and of the manner in which one anatomical stage passes into the next." And yet he incidentally recognized the equality of physiology and morphology by remarking that "geology is, as it were, the biology of our planet as a whole. In so far as it comprises the surface configuration and the inner structure of the earth it answers to morphology; in so far as it studies changes of condition and their causes it corresponds with physiology."

This supremacy of morphology continued well on into the nineties, but about ten or twelve years ago signs of a change began to appear, and no one who has observed even superficially the progress of biology during the last decade can have failed to perceive an immense and increasing interest in general and comparative physiology, accompanied by a decline of interest, relatively speaking, in pure morphology. Investigations in chemical physiology, mental physiology, embryological physiology, cytological physiology, comparative physiology, and in the general physiology of the response and the behavior of animals, have rapidly come to the front, while the field of vegetable physiology is being cultivated as never before. In its various aspects general physiology is to-day probably receiving from investigators more attention than special or mammalian (including human) physiology, and displacing in the hands of zoologists, to a remarkable extent, more strictly morphological studies of a systematic, phylogenetic or ontogenetic character.

Twenty years ago to be a zoologist meant to be a morphologist, but to-day many professors of zoology are either becoming or have already become veritable physiologists. Most of the "experimental zoology" and "embryology" of the present is really general physiology. So also are large parts of physiological chemistry, physiological psychology, cytology, protozoology, microbiology and bacteriology. Hygiene, climatology, experimental medicine, pharmacology, and many other modern branches of biology are also chiefly physiological rather than morphological. Foster's guarded prophecy of 1885 had an almost hopeless tone, for he put "most distant," and in "the far future," the day when "perhaps" morphology and physiology will come together once more; and here again, for the thousandth time, prediction touching the future of science has proved to be empty and vain—for scarcely had a score of years gone by before Foster's "most distant" day was already brightly dawning, and physiology and morphology were again "joining hands" in experimental zoology. So far, indeed, has this movement extended that even the general biologist may now claim the workers in the newer fields as immigrants into his own, pointing with pride to the breadth

and depth of their work as justifying that still older idea of physiology in which it was essentially what we now call "biology;" or even that oldest idea of all, in which physiology was the equivalent of the *ultima thule* of all these sciences, "natural philosophy"—a term hallowed on its mathematical side by the name of Isaac Newton, and in its entirety reaching back to the pupils of Aristotle.

That the recent expansion of physiology is not really a new departure but rather a return to an older as well as a more normal condition, is another interesting fact. In 1854 there was published in London, and republished in America, the fourth edition of a thick volume of 700 pages by Dr. W. B. Carpenter, on "Comparative Physiology," an examination of which shows that the zoologists of that day were fully alive to many of the very problems upon which so many of our modern zoologists are engaged at the present time. The first thing that strikes us in this work is the fact that plants and animals, some high and some low in the scale of life, are equally considered, and always side by side. It is, therefore, really a treatise on general biology. The next is that physiology ordinarily so called, that is to say, human physiology, is nowhere much in evidence. We also find that functions, rather than organs, are dwelt upon, and the general functions of organisms—such as alimentation, nutrition, reproduction, and the liberation of heat, light, and electricity—as well as the special functions of organs—absorption, circulation, respiration, and the like; the general functions always in plants as well as animals. It was therefore truly a *comparative* physiology.

Dr. Carpenter's work was published the year before I was born, but when, as a special student of biology twenty years later, I began the study of physiology, the book was never mentioned and the subject never touched upon, both being apparently little esteemed if not actually forgotten. It was very likely this work that Foster had in mind when he wrote in the context to the passage quoted at the outset of this article: "In its more general meaning physiology was largely used of old, and is still occasionally used in popular writings, to denote an inquiry into the nature of living beings. * * * In its older sense * * * (it)

corresponded to what is now called biology." Recalling the fundamental, original and epoch-making "Handbuch" of Johannes Müller published in Germany between 1834 and 1840 (and in English from 1837) and Carpenter's text-book just referred to on "Comparative Physiology," published in England and America in 1854, we are compelled to regard the present remarkable development of physiology as not merely an expansion, but also a renascence or revival—a return, as it were, to an earlier normal.

The question naturally arises, How did it happen that general and comparative physiology, after beginnings so brilliant, was virtually eclipsed from the time of Carpenter to that of Verworn —(for Claude Bernard's "Leçons sur les phénomènes de la vie communs aux animaux et aux végétaux" published in 1878, had at the time very little general effect, and were hardly more than a succès d'estime). Why was it, we may well inquire, that the pendulum of biological research and teaching swung so far over to the morphological side, while mammalian and medical (or human) physiology rapidly advanced—at least in Germany—separated itself from anatomy, a branch of morphology, and secured for itself important and independent recognition with sustaining professorships?

To this question the answer is, I think, extremely simple—the dates mentioned, and the fact that the phenomenon was most marked in English-speaking countries, giving us the proper clue. In all probability the rapid rise of interest in general morphology and the corresponding neglect of general physiology after 1860 were alike due to the almost complete and universal absorption of biologists, and especially English-speaking biologists, in the problem of the origin of species. For getting light upon this all-important problem, studies in morphological embryology, in comparative anatomy and in systematic zoology and botany were simply indispensable as sources of evidence bearing upon the doctrine of descent, and hence studies ontogenetic and phylogenetic, rather than physiologic, were for the time being enthusiastically and almost exclusively pursued. That medical physiology did not suffer a similar total eclipse by morphology, but rather continued to advance

(at least in Germany) until in 1881 Stanley Hall could describe it as "'The' German Science," was obviously because of its technical importance to medicine. That it flourished in Germany and not in England was doubtless due partly to the persisting influence of Johannes Müller's great work and partly to the fact that the struggles over Darwinism were severest and most distracting on English soil.

Whatever the reason, it had somehow come to pass that in the eighties there was nowhere any physiology to speak of outside the medical schools (while that inside these schools was often of the poorest), and that my own generation grew up almost totally ignorant of general and comparative physiology. If the reason, as seems likely, was the rise and all-embracing influence of Darwinism, we may perhaps be pardoned if Verworn's innocent remark, that the doctrine of descent has not thus far "been fruitful in physiology," seems to some of us far within the truth as not to touch it. But at last, when, after nearly forty years, descriptive embrology and the phylogeny of animals and plants had been well worked out, and when even the noise of the great struggle over the origin of species had mostly died away, opportunity came for that remarkable expansion of physiology which we are now witnessing and which, if I am right, is not merely an expansion, but a renascence. It is a renascence, however, not like the great period of that name in history, preceded by a dark or middle age in general knowledge, for between 1854 and 1894 a splendid development of all other sciences had taken place, theological bonds had been broken, and the freedom of speech and of research enlarged and strengthened. Chemistry and physics had wonderfully expanded and developed and were ready to shed new light upon physiological processes, so that we might say once more, and may to-day repeat with renewed confidence, what George Henry Lewes said before the eclipse—"The hope of science at the present day is to express all phenomena in terms of dynamics."

As for the importance of the revival and of the recent expansion of physiology for biology, making of the latter once more that rounded whole—*totus teres atque rotundus*—which it ought to be, it is difficult to exaggerate. If, as we believe, biology is

only the chemistry and physics of living matter, and if our hope "is to express all phenomena in terms of dynamics," we cannot but rejoice that having accumulated within the last fifty years a vast and precious store of morphological material we may now pass on to the investigations of questions of the relation, causation and coordination of activities; of processes rather than homologies, of behavior rather than form, or mechanism rather than framework. I am informed by an excellent authority that a similar tendency is apparent in medicine itself, and that to-day the processes rather than the results of disease occupy the center of interest in pathology.

Clerk Maxwell long ago remarked concerning biology, that "sciences of this kind are rich in facts, and will be well occupied for ages to come in the coordination of these facts." Surely it is a matter for rejoicing that physiology is to-day dealing with a wider range of facts than ever before. It is no longer confined within medical schools, in which mammalian, or at least vertebrate, facts must always be of paramount importance, for, as has been shown above, zoologists and botanists in our universities and colleges are turning their attention to the behavior and activities of the lower forms of life, both plant and animal. It is, however, unfortunate that the beginner still generally finds no physiology, under that name, offered in our higher institutions of learning outside the medical schools, in which physiology is necessarily, and rightly enough, influenced to a great degree by the needs of technical students, since—as Huxley said long ago —"a medical school is a technical school: a school in which a practical profession is taught." For while physiologists have abundantly demonstrated that pure science may thrive in a technical atmosphere, still, it must always be true that in a technical school the applications of science will be most in demand, and hence most influential. Instead of reproving medical physiologists for their failure to cover the whole field we ought, however, to be grateful to them for having stuck to their guns so devotedly after all other physiologists, both general and comparative, had deserted the field and followed after morphological gods, such as embryology, homology and phylogeny. At last, however, the zoologists and botanists are re-

turning to their own and taking up their old work. It is greatly to be hoped that some of these may eventually come to acknowledge themselves physiologists, and that, very soon, students of biology in our higher institutions of learning, whether zoologists or botanists, may have offered to them equal opportunities in general or comparative morphology and general or comparative physiology. (An excellent *résumé* of present tendencies may be found in the various addresses in Vol. V., Congress of Arts and Science, Universal Exposition, St. Louis, 1906).

Meantime, what is most important is to realize that physiology is still and always will be one of the two grand divisions of biology; that it offers, to-day, especially in its general and its comparative divisions, a field white for the harvest and—what makes it still more inviting—one mostly unworked since the publication of the origin of species. When we realize these facts and also what a wealth of new knowledge the progress of other sciences such as chemistry and physics has placed at our disposal since 1860, it is clear that to general physiology we may probably look in the immediate future for the greatest advances in biology. We have already got from medical physiologists the broad outlines of the physiology of animal organs and from plant physiologists of the organs of plants; we are getting from the experimental zoologists—and particularly the embryologists and cytologists—the physiology of animal cells, including various protoplasms. Our next great advance must come in the physiology of organisms as wholes, and that not merely of the lower organisms, but of the higher also. In this direction studies on nutrition are already beginning to tell, and epidemiology has much to teach. When climatology—a science of rare possibilities—and the numerous divisions of public hygiene shall have "coordinated their facts," we shall have at least the groundwork of a complete physiology of the higher organisms.

The discussion which is to follow—a discussion possible indeed only after morphology had cleared the way—should afford in a consideration of the actions and reactions between parasitic protozoa and mankind, an excellent example of the broader general physiology of to-day and to-morrow.

## PAPERS READ.

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THE PROTOZOA FROM THE STANDPOINT OF THE GENERAL NATURALIST. BY EDMUND B. WILSON.

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SOME GENERAL PRINCIPLES IN CONNECTION WITH PROTOZOA AS FACTORS IN DISEASE. BY C. W. STILES.

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THE PROTOZOAN SPECIES. BY GARY N. CALKINS.

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THE MORPHOLOGICAL DIAGNOSIS OF PATHOGENIC PROTOZOA. BY JAMES EWING.

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IMMUNITY AGAINST TRYPANOSOMES. BY F. G. NOVY.

# EXECUTIVE PROCEEDINGS.

# EXECUTIVE PROCEEDINGS.

## REPORT OF THE GENERAL SECRETARY.

The fifty-seventh meeting of the American Association for the Advancement of Science was held at Columbia University, New York City, December 27, 1906, to January 2, 1907.

The registered attendance of association members was 934. This places the meeting as the fifth in order of size. It was exceeded in attendance by the meetings at Philadelphia in 1884 (attendance 1,261), Boston in 1880 (997), Washington in 1902–3 (975) and Montreal in 1882 (937).

The average attendance at the last twenty meetings of the association preceding the New York meeting was only 458, about one-half as great as at the New York meeting.

The above figures are from the registration at the central registration office up to five o'clock on December 31. The registration of attendance of three sections of the association was known to be incomplete at that time on account of an accident which interfered with the arrangements for registration. It is believed that the total number of persons in attendance at the meetings of the association and affiliated societies was not less than 1,500, placing it first in rank among meetings of the association.

The following shows the registered attendance by sections: A—Mathematics and Astronomy, 80; B—Physics, 104; C—Chemistry, 106; D—Mechanical Science and Engineering, 25; E—Geology and Geography, 115; F—Zoology, 181; G—Botany, 139; H—Anthropology, 57; I—Social and Economic Science, 24; K—Physiology and Experimental Medicine, 61; no preference indicated, 42.

The geographical distribution of the 934 members who registered is as follows; 300 from New York; 110 from the District of Columbia; 96 from Massachusetts; 82 from Pennsylvania; 44 from New Jersey; 44 from Ohio; 30 from Connecticut; 25 from Illinois; 17 from Rhode Island; 17 from Canada; 14 from Maryland; 14 from New Hampshire; 12 from Michigan; 11 from Virginia; 11 from Missouri; 10 from Wisconsin; and less than ten from each of twenty-four different states. Two persons registered from England and one each from Ireland, Cuba and Japan.

Four hundred and eleven new members were added to the association at this meeting. Of these about 350 are due to the activity of the local committee, which had, moreover, previously sent nominations in of about 125 members.

Ten papers were furnished to Section A. These papers were presented before the one joint session with the Mathematical Society and the Astronomical Society or were merged in their programs.

Section B had ten papers on its program, and the American Physical Society had twenty-seven papers. The papers were presented in joint sessions.

Section C met in joint session with the American Chemical Society, at which one hundred and twenty-three papers were presented. The large number of papers required that the section be divided into sub-sections of inorganic, organic, industrial, agricultural and sanitary, physical and biological chemistry, each presided over by a special chairman who added to the interest of the meeting by an address on his special branch of chemistry. Although the registered attendance of Section C was but little more than 100, the secretary of that section states his belief that about 300 chemists were present at the meetings.

Nine papers were presented before Section D (Engineering).

Section E held two independent sessions for the reading of papers; it also held four joint sessions with the Geological Society of America, the sessions being held in two sub-sections. Ten papers were presented to the section, and more than sixty papers were presented to the Geological Society.

Section F held joint sessions for the reading of papers with the American Society of Zoologists, at which about eighty papers were presented. There was also held a joint session with Section G for the reading of papers on plant and animal breeding. The secretary of the section says that the attendance at the meetings was from 100 to 300.

Section G held three independent sessions for the reading of papers. About thirty papers were presented. Members of the section also took part in one joint session with Section F, and attended largely the meetings of the Botanical Society of America, one of which was held at the Botanical Garden in Bronx Park.

The program of Section H and its two affiliated societies contained forty-nine papers.

The programs of Section I, including the joint session with the Anthropological Association and Section H, contained eighteen papers.

Section K, together with its affiliated societies, held four sessions.

Much more than one-half of the papers of the meeting belonged to the affiliated societies rather than to sections of the association. From this point of view the meeting was a confederation of affiliated societies to a greater extent than it was a meeting of a group of sections of a compact organization.

The subject of the address of the retiring president of the association, Professor C. M. Woodward, was "The Science of Education." A vice-presidential address was delivered before each section.

The relations between the sections and the affiliated societies were entirely harmonious, the officers cooperating with each other in making arrangements for meetings.

Columbia University placed its buildings at the disposal of the association and the greater number of sections met at the university. Certain meetings were held elsewhere, notably, the meetings of Section K at the Rockefeller Institute and at the College of Physicians and Surgeons. Appropriate thanks were tendered by the president of the association at the closing general sessions to the local committee, the authorities of Columbia University, and to many others who, in their capacities as hosts, contributed to the success of the meeting.

The following general events contributed to the success of the meeting and the pleasure of those in attendance: (1) A reception by the president of Columbia University at Earl Hall on Thursday evening; (2) a general meeting with addresses and luncheon at the College of the City of New York at noon on Saturday; (3) on Saturday afternoon exercises at the American Museum of Natural History, connected with the unveiling of the busts of ten American men of science, presented to the museum by Mr. Morris K. Jesup; (4) on Saturday evening a gathering at the museum to see the collections and special exhibits arranged for the occasion. The cultivation of acquaintance among the members was also promoted by many smokers, dinners and other special events which brought various groups together. The reception at Earl Hall on Thursday evening was probably the only occasion at which one found so large a gathering of members at any one place as to give the idea that this meeting of the association was an unusually large one. Probably most members did not realize that they were attending one of the largest if not the largest meeting of many years.

The most important actions taken by the council and the association were as follows;

1. The addition of a new section to the association, namely, Section L—Education. A petition in favor of the formation of such a section was presented to the association to which were affixed the signatures of 171 men, including many of the most prominent educators.

2. The title of Section H was changed from "Anthropology" to "Anthropology and Psychology."

3. The permanent secretary was authorized to publish hereafter the programs of the affiliated societies as a part of the official program of the association.

4. Section E, and other sections desiring to do so, were authorized to hold meetings in the summer of 1907.

5. A standing committee of fifteen on seismology was appointed. The committee consists of G. K. Gilbert, U. S. Geological Survey; Cleveland Abbe, U. S. Weather Bureau; L. A. Bauer, Carnegie Institution; C. E. Dutton, U. S. Army; H. F. Reid, Johns Hopkins University; Otto Klotz, Observatory, Ottawa, Ontario; W. W. Campbell, Lick Observatory; A. C. Lawson, chairman, California State Earthquake Commission; R. S. Tarr, Cornell University; L. M. Hoskins, Stanford University; C. G. Rockwood, Jr., Princeton University; W. H. Hobbs, University of Michi-

gan; W J McGee, St. Louis; John F. Hayford, U. S. Coast and Geodetic Survey; and T. A. Jagger, Jr., Harvard University.

6. A standing committee of five on the bibliography of science was appointed, one of whose duties shall be to cooperate with the International Catalogue of Scientific Literature. The committee consists of J. McKeen Cattell, R. S. Woodward, Jas. Lewis Howe, Wm. Trelease and C. B. Davenport.

7. A Darwin Memorial Committee of ten was appointed to consider the manner in which the American Association for the Advancement of Science may suitably commemorate the fiftieth anniversary of the publication of the first edition of the "Origin of Species." The committee consists of H. F. Osborn, chairman, L. O. Howard, E. G. Conklin, A. C. Lane, D. T. MacDougal, J. McK. Cattell, J. M. Colter, H. B. Ward, F. Boas and C. B. Davenport, secretary.

8. Grants for research were made as follows: $100 to the Concilium Bibliographicum; $100 to Professor Frederick E. Clements for aid in the study of the relation of Alpine plants to their environment; $100 to J. Arthur Harris for aid to complete a statistical investigation of the influence of environment on the characteristics of organisms. The last two recommendations were made on the understanding that the grants will be expended under the supervision of the standing committee on the relations of plants to climate.

9. The Entomological Society of America was admitted to the privileges of affiliation.

10. The council recommended that the committee on the policy of the association be requested to consider means by which the efficiency of the organization of the association may be increased and the office of the permanent secretary be made more important, and that the consideration of these matters be made to include the following points: procuring a permanent secretary to devote his entire time to the work of the association and to receive greatly increased pay; the matter of raising the dues of the association; the matter of dropping the entrance fee of the association; the matter of changing the time of convocation week and of the meeting of the association; and the relation of the association to the affiliated societies.

11. It was decided to hold the next regular meeting of the American Association for the Advancement of Science at Chicago in the winter of 1907–8, and not to hold a summer meeting in 1907.

12. It was recommended to the next general committee that a meeting be held in the summer of 1908, preferably in some New England town, and that the regular meeting during convocation week in 1908–9 be held in Baltimore.

The officers elected for the ensuing year were:

*President*—Professor E. L. Nichols, Cornell University.

*General Secretary*—President F. W. McNair, Michigan School of Mines.

*Secretary of the Council*—Professor Wm. Harper Davis, Lehigh University.
*Vice-presidents of the Sections:*
A—Professor E. O. Lovett, Princeton University.
B—Professor Dayton C. Miller, Case School of Applied Science.
C—Professor H. P. Talbot, Massachusetts Institute of Technology.
D—Professor Olin H. Landreth, Union College.
E—Professor J. P. Iddings, Chicago University.
F—Professor E. B. Wilson, Columbia University.
G—Professor C. E. Bessey, University of Nebraska.
H—Professor Franz Boas, Columbia University.
I—Dr. John Franklin Crowell, New York City.
K—Dr. Ludvig Hektoen, Chicago University.
L—Hon. Elmer E. Brown, U. S. Commissioner of Education.

*Secretary of Section B*—Professor A. D. Cole, Ohio University, for five years.

*Secretary of Section I*—Professor J. P. Norton, Yale University, for five years.

*Secretary of Section L*—Professor Edwin G. Dexter, University of Illinois, for five years.

*The Sectional Committee of the New Section,* "L" (Education)—President, David Starr Jordan, Leland Stanford University; President Charles S. Howe, Case School of Applied Science; Professor Thomas M. Balliet, New York University; Professor E. L. Thorndike, Columbia University; Professor C. M. Woodward, Washington University.

The minutes of the opening general session in Earl Hall on December 27, together with the addresses, are appended to this report.

JOHN F. HAYFORD,
*General Secretary.*

PROCEEDINGS OF THE OPENING SESSION.

President C. M. Woodward in the Chair.

Professor WOODWARD: The American Association for the Advancement of Science will please come to order. In opening this meeting, ladies and gentlemen, and before I perform my simple official duty of introducing the new president, I cannot avoid saying what a joy it is, what a delight it is, to meet such a congregation of scientific men. As one looks down the fifty-nine years which this association has lived and has seen how from a few hundred it has grown to four thousand members, and how many splendid things it has performed in one way or another, all in the interests of science and making that science meet the needs of man in this great community, it is a time for congratulation; and I feel especially proud to be for the moment a representative of such an organization. And with this word of greeting to you and of congratulation for the association, I take great pleasure in presenting to you the president-elect, who will

preside over our deliberations and lead us forward during the few days that we now meet together, Doctor W. H. Welch, of the Johns Hopkins University, who is to be president for the coming year—Doctor Welch.

Doctor WELCH: Ladies and gentlemen, this is not the first meeting of the association over which I have had the honor to preside, inasmuch as the old custom of holding a midsummer meeting was revived last summer. Before this larger gathering of the association I desire to renew the expression of my thanks and of my profound appreciation of the honor conferred upon me by election to this high office. I interpret this honor above all as a recognition of the position held to-day by medicine in its relations to general science, and it is especially as an honor conferred upon the science of medicine that I beg to acknowledge your action in selecting me to preside over this association of scientific men and women.

We shall now have the pleasure of listening to words of welcome from the president of Columbia University, Dr. Butler.

President BUTLER: Mr. President, ladies and gentlemen, it is a pleasure, and no small satisfaction, speaking on behalf of my colleagues in the university—trustees, faculties, alumni and students—to offer you a cordial and hearty welcome to our home. Nowhere in America, perhaps, could you by any possibility receive a warmer or more sympathetic welcome than here. We are so fortunate as to count among our university membership a very considerable proportion of the membership of your association, and we look to them to lead and to guide and organize our university policies and opinions in the field of the sciences of nature and of man. Whatever facilities we may have for making you comfortable and happy are wholly and entirely at your service, and our part will be played to our own satisfaction if, when the hour of adjournment comes, you shall feel that nothing has been left undone that thought or care could do to provide in every way for the success of this gathering and for this most important meeting.

I might perhaps stop here, because, after all, there is not much to be gained by repeating a formal invitation that is once given with sincerity and heartiness; but I can not resist the opportunity to say just a word in addition to my word of welcome. I am one of those who now for nearly thirty years has observed at first hand the slow, and then the rapid, advance of the sciences to their present place in the school and college programs of this country. It has been my fortune to listen to and sometimes to participate in the discussions and debates which have accompanied that advance. So far as I now recollect, every vote that I have had to give has been given in its favor. But now at the end of this period I can not help feeling, as I observe from reading the literature of the subject that the same feeling is shown in England, in France and in Germany, that we have not yet succeeded in so organizing the sciences as instruments of general education as to fulfil the high expectations which some of us formed for them nearly a quarter of a century ago.

This is a subject which I respectfully commend to the study of this most representative and competent body. What is it that remains to be done, and what should we here do, so to correlate and organize and present the subject matter and the methods of the sciences as to increase their effectiveness as educational instruments?

I say with great frankness that if we did not know that we are going through what is doubtless a period of transition, the movement in which we have all been participating has cost us something and gained not much. But we are going through a period of transition. Perhaps we are expecting too much and too soon, but my purpose in saying what I now say is to bring to your attention the fact that to many of us the consideration of the educational effectiveness of the sciences touches the whole field of human interest, of human knowledge and of human activity.

There can be little doubt that the sciences of nature and of man, properly organized and presented as educational instruments, are destined to be classified as true humanities. I can not help feeling that in addition to their power to instruct and inform they have a power to refine, to uplift and to guide; but I am quite confident that as yet we are very far short of having so organized this material as to attain these ends.

I hope very much that the next decade may see intensive study of this aspect of these scientific problems and of scientific work; and that out of it all may come, not a larger place in the educational program for the sciences, because that would hardly be possible—but a more effective and more uplifting and a more humanizing result of teaching the sciences, in order that we may pass on to the next generation this new educational instrumentality organized and perfected for true educational work, which never can be limited to the passing of information from hand to hand or mere instruction in method by master to pupil.

I throw out this suggestion, because here, in this association, are men and women devoting their lives to the study and investigation and presentation of truth, to whom in the colleges and universities, and to whom in the nation at large, we must look for the formulation of the answer to just such questions as this. To them I commend the question at to the proper organization of the sciences as instrumentalities in general education.

I say again you are heartily and completely welcome to this university and whatever hospitality it can offer and every act of friendliness which you will give us the privilege to show.

President Welch responded to the address of welcome as follows:

LADIES AND GENTLEMEN: In behalf of the members of the American Association for the Advancement of Science and of the Affiliated Societies I thank you heartily, President Butler, for your cordial words of welcome, and I assure you and your colleagues that it is most gratifying to us to have the opportunity of meeting in this city and at this university.

It was not until nearly forty years after its foundation that this association met first in the city of New York, whereas this third meeting in New York follows only six years after the preceding one in the same place.

These events in their periods of sequence indicate in a measure the rate of growth of science in this city and its increase of attractiveness to men of science. While for a century and more there have been eminent scientific men in New York City, it is, nevertheless, true that for a long period of time letters and science were not represented in this city in a degree at all commensurate with its position in other respects, and New York thereby lacked a note of distinction in its civic and educational life possessed by several smaller cities and even small towns in this country.

In recent years, indeed in the short interval since our last meeting here, the conditions have changed rapidly, and New York is taking a position in education and the promotion of science more nearly approaching its leadership in commerce and other material interests. The most powerful instrumentality in bringing about this great advance has been Columbia University with the influences which have gathered about it, and it is most gratifying to the members of this association to witness, where we are now assembled, the marvelous growth of this great university. A worthy share in this development of the higher learning has been borne also by New York University, and in our visit to the new buildings of the College of the City of New York, where a general meeting of the association is to be held on Saturday, we shall have the opportunity to behold the visible evidences of the most enlightened liberality of a municipality in support of higher education for the people.

Those interested in natural science will find nowhere a more impressive illustration of municipal liberality in support of an institution for the instruction of the people and the advancement of natural knowledge than the American Museum of Natural History, where on Saturday evening we are to be the guests of the trustees of the museum and of the council of the New York Academy of Sciences, this latter organization ranking also among the important forces contributing to the development of science and of the scientific spirit in this city, and adding much to the interest of our meeting by the admirable exhibition and demonstrations of recent scientific progress which it has arranged in the museum. No feature of our meeting will afford greater pleasure and inspiration than the ceremonies attending the unveiling of the busts of American men of science presented to the museum by Mr. Morris K. Jesup, to whose generosity, public spirit and individual efforts American science is so deeply indebted. I wish to acknowledge at this time the courteous thoughtfulness of the trustees of the museum, not only for their hospitality, but also for selecting the time of our meeting for these interesting ceremonies.

The Metropolitan Museum of Art, with its magnificent collections in art and archeology, like the American Museum of Natural History, sets an example to the national government in the cultivation of the sciences and the fine arts.

Our botanical members at their meeting at the New York Botanical Garden will find there, as well as in the adjacent Zoological Park, in the

opportunities afforded for the study of science and for the delight of the people, another and kindred illustration of the wise liberality of this city.

The New York Public Library, with its magnificent new building approaching completion, is another splendid foundation, resting upon both private and public munificence, which ranks among the great educational institutions of this city, whose growth and widened usefulness in recent years are significant of the progress of learning and science.

The holding of meetings of one of our sections and of affiliated societies in the new building of the Rockefeller Institute for Medical Research will afford opportunities to inspect laboratories unsurpassed in their arrangement and equipment for investigation in those branches of medical science to which they are devoted. In this connection I may state that New York City leads the world in the application by its department of health of the great discoveries of the last quarter of a century in bacteriology to the prevention of disease.

Time forbids further illustration of recent scientific progress in New York City. I have cited as examples mainly institutions with which the association will be brought, during our meeting, into some personal contact through their hospitality, and they will suffice to demonstrate the rapid and most gratifying development of higher education and of interest in the sciences of man and of nature in this city.

President Butler in his opening remarks has touched upon a subject most timely and important for the consideration of such men and women as constitute the membership of this association, and we shall do well to ponder carefully words on this theme coming from so high an authority upon education. While expressing sympathy with the aims of the natural and physical sciences, recognizing their importance and supporting them, as he has done, he also expresses the opinion that science in the general scheme of education and as an educational instrument has not fulfilled the expectations which he and others entertained regarding it a quarter of a century ago. While it is not possible to discuss this subject adequately on this occasion, I may be permitted to say a few words regarding it.

It is doubtless true that during the relatively short time since the natural sciences were admitted to the curriculum of a liberal education the teaching of these sciences has not attained to that agreement of opinion and fixity of method which centuries of use as instruments of education have secured for the classical languages and mathematics. It must be admitted that methods of teaching the natural sciences have often been unsatisfactory and have, therefore, yielded unsatisfactory results. The subject is one for serious consideration, to which many of our teachers are, I think, alive, and it is a satisfaction to announce that the council at its meeting this morning, in response to a wide-spread and influential demand, recommended the formation of a new section of this association to be called the "section on education," which, we may hope, will contribute to the best methods of teaching the sciences.

It may also be admitted that exaggerated claims have sometimes been made as regards the position which the natural sciences should hold in the scheme of general education and as regards the extent and kind of mental discipline, culture and knowledge which, when pursued in such a scheme, they are capable of imparting. Without attempting to assign to these sciences their exact share in a plan of liberal education—and this share, I need hardly say, I deem an important one—I should be sorry to see eliminated from the education of even those looking forward to scientific pursuits the study of the languages, history and philosophy, which give a culture not to be derived solely from the study of the natural sciences and which should add greatly to the intellectual pleasure, satisfaction, breadth of vision, and even efficiency of the man of science. Natural science should take its place in a plan of liberal education by the side of the older learning, the so-called humanities; each affords a kind of culture not to be obtained from the other, and any scheme of higher education which does not recognize the equal value of both kinds of culture is one-sided.

The full recognition of the part thus assigned to natural science in liberal education requires an adjustment on the part of the exclusive advocates of the traditional system handed down from the middle ages to new ideals of what constitutes liberal training, but in this field science has won its victory and will not be dislodged. It is, however, not enough to be content with this victory. Science should see to it that in its own field it becomes an instrument of education certainly not less powerful than the older humanities, and President Butler has very properly urged the need of improvement in this direction.

Standing here, as I do, as a representative of medicine in an association devoted to all the sciences of nature, the relation of medicine to general science comes prominently to my mind. Medicine has been called the mother of the sciences. There was a time when the leading cultivators of natural science were physicians and when the medical faculties of universities were the homes of about all the science that then existed. In subsequent history physicians have played no small part in the development of the natural and physical sciences. Such important contributors to physical science as Black, Young, Mayer and Helmholtz were all actively identified with the medical profession, and are important figures in the history of medicine as well as of physics. From the study of chemical and physical phenomena of living animals and of man, whether by chemists, by physicists or by physicians, have come important additions to the sciences of chemistry and of physics, and medicine is constantly finding new and important applications of chemical and physical discoveries. We realize to-day as never before the fundamental unity of the biological sciences, and answers to the deepest and most far-reaching problems of medicine, not less than of other biological sciences, are to be sought in the properties of living matter, wherever it exists, whether in plants or in animals or in man.

Medicine has during the past half century entered irrevocably upon the true paths of science. Dogma and transmitted authority are no longer its guides, but it seeks for truth by the only methods found fruitful for all science—experiment, observation and just inference.

The domain which has been opened to medicine during the last quarter of a century by the introduction of new methods and resulting discoveries in the causation of infectious diseases has greatly increased our power to cope with disease, and the masterful pioneers in this new field, Pasteur and Koch, rank among the greatest benefactors of mankind. The wider recognition by governments and by the people of the humane, the economic and the social value of this power of preventive medicine to check incalculable suffering and waste of energy from disease, is urgent. One of the most gratifying exemplifications of the useful functions of this association is the initiation by the section on social and economic science of an influential movement for the establishment by the national government of a bureau or department of public health.

This leads me, in closing, to say a few words concerning the scope and aims of this association. Our retiring president, in his introductory remarks, spoke of the great growth of the association, which has more than doubled its membership during the six years since we last met in New York. At its foundation and for many years afterwards this association supplied all that was demanded of a national society representative of the various natural and physical sciences. In later years specialization, at once a cause and a result of the great progress of science, has led to the formation of many special scientific societies of national scope, and the end is not yet in sight. It became evident several years ago that the association, in order to retain its usefulness, if not its life, must adjust itself to the new conditions, and this it did by taking the position of a central organization of science with which the various special societies, while remaining autonomous, should become affiliated and constituent units. It cannot be doubted that the broad conception underlying this readjustment is the correct one and that its application has already been attended by a large measure of success.

There remain, however, certain difficulties to be overcome and certain problems to be solved before this association shall have attained that ideal of organization and of usefulness to which we may reasonably look forward. The need of such a central, national organization as a coordinating, unifying, harmonizing influence, as an authoritative representative and exponent before the public of scientific opinion and of scientific workers, as an instrument to secure cooperation among scientific investigators, to influence public opinion, to advance the interests of science as a whole as well as to inaugurate and to secure support for special scientific undertakings and lines of investigation, and as a means of securing that most desirable purpose, placed first among the objects of the association in its constitution—"to promote intercourse between those who are cultivating science in different parts of America"—the need, I say, of a central

organization with these aims and others which might be specified, demands, I think, a wider and deeper appreciation among the scientific men and women of this country. Especially should our leaders in science realize, as many of them do, the great possibilities of usefulness of this association and work actively for the promotion of its welfare. Larger financial resources are needed to perfect the organization and to enable the association to cultivate more fruitfully the fields which it already occupies and to enter new ones. Within the near future the membership should rise to at least ten thousand. With its history of honorable achievement and its present success this association may confidently look forward to a future of greatly increased power and usefulness for the advancement of science.

I now declare open this fifty-seventh meeting of the American Association for the Advancement of Science, and in so doing I express the hope which our program indicates to be indeed an assurance, that the sessions and social functions of the association, of the various sections and of the affiliated societies, may be full of interest, pleasure and profit to those in attendance.

## REPORTS OF COMMITTEES.

### ON ELECTROCHEMISTRY.

Through the courtesy of the Research Laboratory of the General Electric Company, we were presented with two tantalum electrodes and it has, therefore, not been necessary to draw on the grant. Last year it was found that the reaction between chlorine and water in sunlight was accelerated markedly by the presence of iridium and only very slightly by platinum. This year it has been found that the reverse reaction, between oxygen and aqueous hydrochloric acid, does not take place to a measureable extent in presence of iridium whereas it apparently does in presence of tantalum.

A hydrochloric acid solution, saturated with chlorine gas, was electrolyzed, using an iridium anode illuminated by an arc light. No gas was given off at the anode and consequently equilibrium conditions were not reached. The reason for this unexpected result is apparently that the electrolyte attacked the substances which had been used to protect those portions of the anode which were not exposed to light. This matter is still under investigation.

WILDER D. BANCROFT,
EDGAR F. SMITH,
LOUIS KAHLENBERG.

## On Biological Variation.

The greatest progress of the last few years has been made in the study of the classification and inheritance of variations. It has become more completely realized that most of the differences that distinguish two species or even two varieties are of the order of mutations; *i. e.*, they are non-blending characteristics in hybridization and have probably arisen suddenly, fully formed. Even in the case of apparently graduated characters, the extremes crossed together often do not blend, but behave as unit characters and are inherited in Mendelian fashion.

The part of the subject of variation most in need of present investigation is that of the cause of mutations and their artificial production. A beginning has been made in this sort of investigation, enough to show that important progress may be made by properly directed experimentation.

C. B. Davenport,
*Recorder*

## On the Teaching of Anthropology in America.

*To the Council of the American Association for the Advancement of Science:*

Your committee on the teaching of anthropology in America beg to report progress. When the committee was created some years ago, few American institutions of learning recognized either the need or the nature of anthropologic teaching; and the committee engaged in extensive correspondence with universities and colleges and submitted reports to Section H and through the Section to the Council. Since the Washington meeting in 1902, correspondence with educational institutions has been intermitted and the work of the committee has been relaxed chiefly because effort seemed hardly opportune; but of late it has been thought timely to renew representations to educational institutions concerning the growing importance of anthropologic teaching, and your committee plan a renewal of correspondence and publication. To this end, it is recommended that the committee be continued with power to add to its number.

Respectfully submitted,

W J McGee,
George Grant MacCurdy,
Franz Boas.

## On Grants.

The committee on grants of the A. A. A. S. begs to recommend that the following grants be made for the year ending December 31, 1907:

| | |
|---|---|
| (1) To the Concilium Bibliographicum ..... | $100.00 |
| (2) To Frederick E. Clements for aid in a study of the relations of Alpine plants to their environments..... | 100.00 |

(3) To J. Arthur Harris for aid to complete a statistical investigation of the influence of environment on the characteristics of organisms..... $100.00

It is understood by said committee that these proposed grants, (2) and (3), will be expended under the supervision of the standing "Committee on the Relations of Plants to Climate."

Very respectfully submitted,

R. S. WOODWARD,
*Chairman.*

## Report of the Treasurer.

In compliance with Article 15 of the Constitution, and by direction of the Council, I have the honor to submit the following report, showing receipts, disbursements, and disposition of funds of the Association for the year ending December 31, 1906.

Receipts have come into the keeping of the Treasurer from one source only, namely, interest on invested funds. The total amount of such interest is $543.50.

Disbursements made in accordance with the directions of the Council amount to $100.

The total amount of funds of the Association deposited in savings banks and with the U. S. Trust Company, and subject to the order of the Treasurer, December 31, 1906, is $16,635.40.

The details of receipts, disbursements, and disposition of funds are shown in the following itemized statement.

Dated April 15, 1907.

THE TREASURER IN ACCOUNT WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

| 1906. | DR. | | |
|---|---|---|---|
| Jan. 1. | To balance from last account | | $16,191.90 |
| Dec. 31. | To amount of interest received from funds deposited in banks, as follows: | | |
| | From Cambridge Savings Bank, Cambridge, Mass. | $38.27 | |
| | From Emigrant Industrial Savings Bank, New York, N. Y. | 120.00 | |
| | From Metropolitan Savings Bank, New York, N. Y. | 110.07 | |
| | From Union Square Savings Bank, New York, N. Y. | 102.66 | |
| | From U. S. Trust Company, New York, N. Y. | 172.50 | |
| | | | 543.50 |
| | Total | | $16,735.40 |

THE TREASURER IN ACCOUNT WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

| 1906. | | CR. | |
|---|---|---|---|
| May 8. | By grant paid to Concilium Bibliographicum | | $100.00 |
| Dec. 31. | By cash on deposit in banks, as follows: | | |
| | In Cambridge Savings Bank, Cambridge, Mass | $1,123.16 | |
| | In Emigrant Industrial Savings Bank, New York, N. Y | 3,146.72 | |
| | In Metropolitan Savings Bank, New York, N. Y | 3,019.01 | |
| | In Union Square Savings Bank, New York, N Y | 2,975.50 | |
| | In U. S. Trust Company, New York, N. Y | 6,172.50 | |
| | In The Fifth Avenue Bank of New York, N. Y | 198.51 | |
| | | | 16,635.40 |
| | Total | | $16,735.40 |

I hereby certify that the foregoing account is correctly cast and properly vouched.

THEO. GILL,
*Auditor.*

L. O. HOWARD, PERMANENT SECRETARY, IN
TION FOR THE ADVANCE-

*From January 6, 1906 to*

DR.

| | | |
|---|---|---|
| To balance from last account | | $12,736.38 |
| Admission fees | $2,035.00 | |
| Annual dues, 1906 | 3,735.00 | |
| Annual dues, 1907 | 7,364.00 | |
| Annual dues, previous years | 552.00 | |
| Associate fees | 30.00 | |
| Life membership fees | 1,350.00 | |
| | | 15,066.00 |
| Publications | $2.44 | |
| Binding | 14.75 | |
| Miscellaneous receipts | 10.16 | |
| Interest | 68.76 | |
| | | 96.11 |

$27,898.49

## ACCOUNT WITH THE AMERICAN ASSOCIAMENT OF SCIENCE.

*January 2, 1907.*

CR.

| | | |
|---|---|---|
| *By publications:* | | |
| To publishers Science | $8,157.09 | |
| Vols. 54 and 55 | 2,967.05 | |
| Authors' extras, announcements, etc | 432.93 | |
| | | $11,557.70 |
| *By expenses New Orleans, Ithaca and (part) New York, meetings:* | | |
| Secretaries of Sections and Press Secretary | $1,313.50 | |
| Programs, clerks, stenographers, etc | 439.51 | |
| | | 1,753.01 |
| *By general expenses including propaganda:* | | |
| Postage | $1,955.37 | |
| Express and telegrams | 42.44 | |
| Extra clerical help | 98.39 | |
| Circulars, forms, stationery and misc | 274.02 | |
| | | 2,370.22 |
| *By salaries:* | | |
| Permanent Secretary | $1,500.00 | |
| Assistant Secretary | 750.00 | |
| Assistant Secretary | 170.00 | |
| | | 2,420.00 |
| *By miscellaneous disbursements:* | | |
| Overpaid dues returned | | 9.00 |
| By balance to new account | | 9,789.19. |
| | | $27,898.49 |

The foregoing account has been examined and found correct, the expenditures being supported by proper vouchers. The balance of $9,789.19 is with the following Washington, D. C., Banks:

| | |
|---|---|
| American National Bank | $6,950.79 |
| National Savings and Trust Co | 1,157.52 |
| American Security and Trust Co | 1,680.88 |

THEO. N. GILL,
*Auditor.*

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PLATE I.

Photo. by G. G. MacC.

LES EYZIES IN THE BACKGROUND; THE VÉZERE RIVER ON THE LEFT (DORDOGNE).

PLATE II

Photo. by G. G. MacC.

ENTRANCE TO THE CAVERN OF FONT-DE-GAUME (DORDOGNE).

POLYCHROME PAINTING OF A BISON. CAVERN OF FONT-DE-GAUME (DORDOGNE). FOURTH PHASE. $\frac{1}{16}$. (AFTER CAPITAN AND BREUIL.)

PLATE IV.

UNFINISHED POLYCHROME PAINTING OF TWO REINDEER, SHOWING HOW PAINTING WAS COMBINED WITH ENGRAVING. CAVERN OF FONT-DE-GAUME (DORDOGNE). FOURTH PHASE. $\frac{1}{10}$. (AFTER CAPITAN AND BREUIL.)

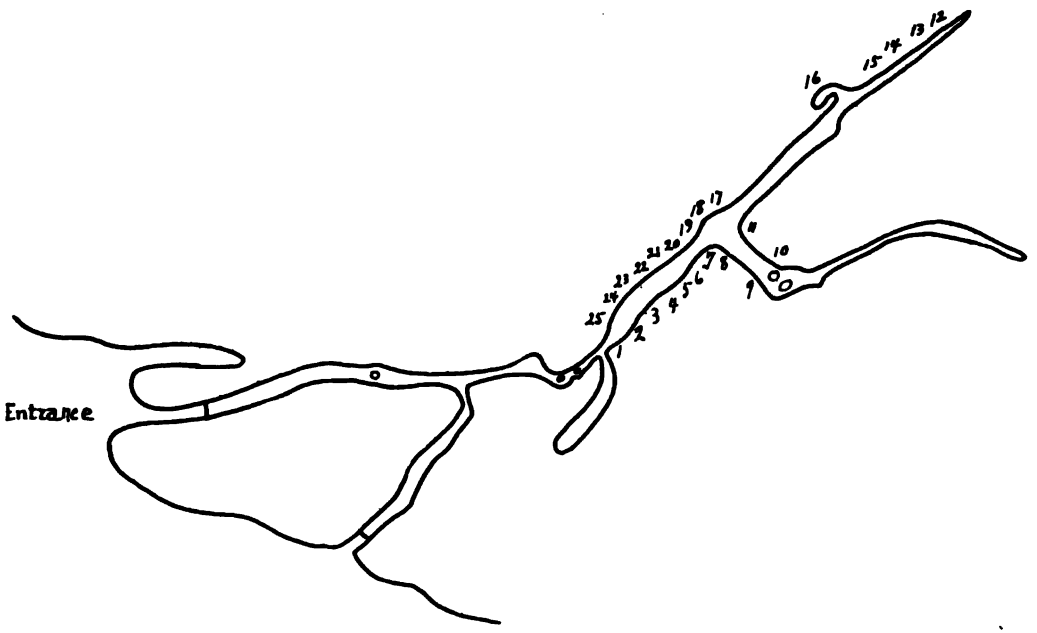


FIGURE 1.—FLOOR PLAN OF THE CAVERN OF FONT-DE-GAUME (DORDOGNE). THE NUMBERS INDICATE THE POSITION OF THE ENGRAVINGS AND PAINTINGS ON THE WALLS.

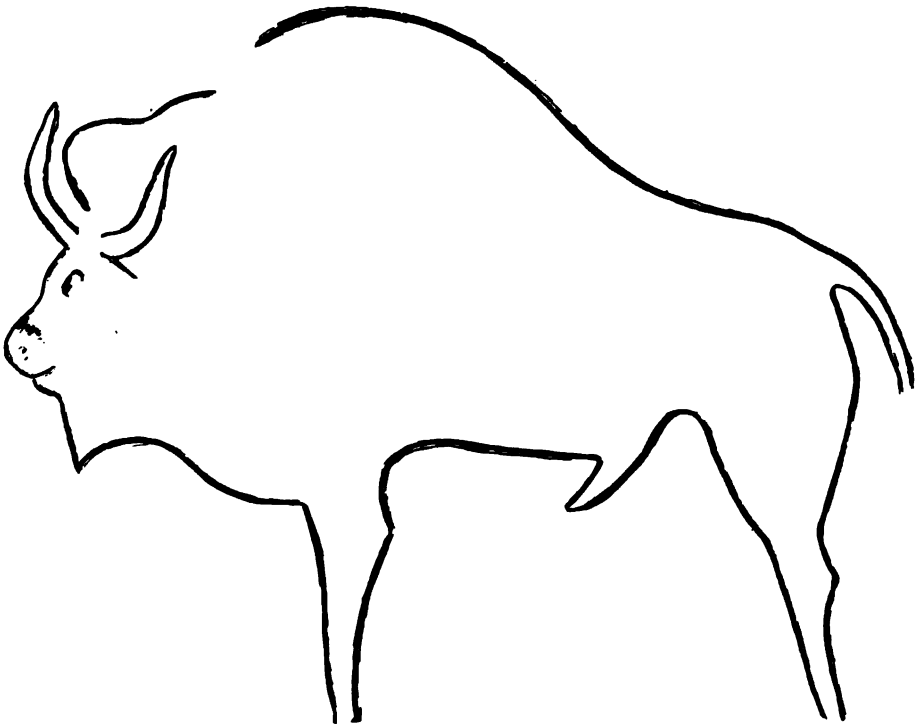

FIGURE 2.—ENGRAVING OF A BISON. CAVERN OF LA GRÈZE (DORDOGNE). FIRST PHASE. ¼. (AFTER BREUIL.)

FIGURE 3.—HEAD OF A HORSE, DRAWN WITH A BLACK CRAYON. CAVERN OF ALTAMIRA. FIRST PHASE. ¼. (AFTER BREUIL.)